CIRCANNUAL VARIATION AND INTERRELATIONSHIP OF ABIOTIC FACTORS WITH THE SOIL DWELLING INSECTS IN AGROFORESTRY HABITAT

DISSERTATION

SUBMITTED FOR THE AWARD OF THE DEGREE OF

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in

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By

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Certificate

I certify that the work presented in this dissertation entitled ***"Circannual variation and interelationship of Abiotic factors with the soil dwelling insects in Agroforestry Habitat"*** *has been carried out by* ***Nisha Sharma*** *under my supervision and is suitable for the award of the* ***M.Phil Degree*** *in* ***Zoology*** *of Aligarh Muslim University, Aligarh.*

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Dedicated

To

My Parents

CONTENTS

Acknowledgement

Acknowledgement

First of all, I must express profound sense of obligations to almighty God for showing immense blessings upon me due to which I could accomplish this academic task.

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Nisha Sharma

NISHA SHARMA

Introduction

INTRODUCTION

Soil and litter habitats have become recognized as important respositories for biodiversity. They are also dominated by some of the smallest animals; the Microarthropods.

Microarthropods inhabiting soil and litter include Springtails, mites, Diplurans, Proturans, Symphylids and psentoscorpions. Springtails and mites dominate this fauna in terms of abundance, biomass, species diversity and their effect on the nutrient cycling process. The majority of springtails feed on fungal hypai or decaying plant material. In the soil, they may influence the growth of mycorrhizae and control fungal diseases of some plants. In general these effects are beneficial.

Soil Microarthropods play an important role in the flow of energy and cycling of nutrient both at the herbivore and decomposer levels in humid to semiarid regions of earth. As with other organism, the magnitude of their ecological role is related to their population density and biomass.

Soil Microarthropods constitute one of the most species rich communities in forest ecosystem (Crossley and Blair 1991). The effect of soil fauna in these systems on decomposition rates, nutrient regeneration and soil structure have been well documented.

The activity of soil dwelling animals is very significant for the fertility of soil. Fertile soil is that soil which provides essential nutrients for crops, plant growth, supports a diverse and active biotic community, exhibit a typical soil structure and allow for an undisturbed decomposition.

There were two sites for study. Grassland and teak plantation comparatively in which we studied the population dynamics of soil microarthropods and their relation with abiotic factors. Grassland site is surrounded by some ornamental plants and regularly look after by garderners under the supervision of horticulturist while the other site Teak Plantation is completely undisturbed teak community. This type of soil management practices will have an influence on the population dynamics of soil microarthropods.

The main objective of our study is to assess:

- Population density of soil microarthropods in below ground.

- Effect of abiotic factors on the population dynamics of soil microarthropods.

Review of Literature

REVIEW OF LITERATURE

Earliest comprehensive work on soil fauna done by Diem (1903) who studied the occurrence of soil fauna in the region of Alps Switzerland. This work was followed by some useful observation in Pedobiology by Shelford (1913), Adams (1915), Thompson (1924), Edward (1929) and Ford (1935), Strickland (1947) used the flotation method for the extraction of soil microarthropods.

Watenova (1964) observed that there is decrease in the population of springtails and mites with the depth of the soil. This decrease was attributed to the factors like the decrease of porosity, CO_2 evolution, carbon contents of the soil and amount of root in each horizon. Jenson and Corbin (1966) performed experiments to evaluate the microclimatic factors causing aggregation in animals. Gill (1969) investigated whether litter determines the abundance of soil microarthropods. He observed that an increase or decrease in the amount of litter in the field produced an increase or decrease on the abundance of microarthropods during summer and winter and not during spring.

An important work on soil microarthropods done by Mukerjii and Singh (1970) who studied the seasonal variation in the densities of Collembola, Acarina, Diplurans Symphyla, Pauropoda in a rose garden at Varanasi. They found that there existed a certain correlation between the moisture content, temperature and the population dynamics of soil microarthropods Choudhury and Roy (1972) observed the population of collembolans reached the maxima in Nov-Jan in an uncultivated plot of West-Bengal. These maxima had a positive correlation with organic carbon $CaCO_3$ average particle size but negatively correlated with moisture.

Vlug and Borden (1973) observed the population density in water logged and burnt forest area were moderate indicating that neither of the two cause induced mortality. There was no seasonal fluctuation and no correlation of the density of population with soil moisture Hydrogen ion concentration and temperature. Wong et al. (1977) observed that Collembola and Acarina were abundant in the soil which had higher contents of organic matter. Block William (1981) studied low temperature effects on microarthropods. A differences in arthropod population structure in the soil of forest and Jhum sites of North Eastern states was observed by Darlong and Alfred (1982). They also found that firstly the population density was maximum in May and minimum in December from the upper soil layers, secondly the population tended to decrease during dry and cold season. According to them, temperature and precipitation are of great importance for the soil fauna.

Verhoef H.A. and Vanselm A.J. (1983) studied the distribution and population dynamics of Collembola in relation to soil moisture. Next important work done by Tamm (1984) who studied the life of terrestrial arthopods living in flood prone areas revealed that collembolans and Acarina undergo a stage of inactivity during submergence and their eggs hatch after the water receeds. The fact that collembolans favour high acidic soil has been conclusively demonstrated by Luxton and Moore (1986). Cannon R.J.C. and Block W. (1988) stated that cold tolerance of microarthropods. In their study, all microarthropods appear to be freeze, susceptible and they utilize varying levels of supercooling to avoid freezing, Moulting may increase individuals supercooling ability especially in Collembola and the activity of ice nucleating bacteria in cold hardy arthropods may be important. Villani M.G. and Wright (1990) studied the environmental influences on soil microarthropods behaviour in agricultural systems.

Vadakepuram Chacko Joy et al. (1991) found that chemicals like aldrin and Endosulphan adversely affect the density of soil microarthropods and especially the Acari and Collembola.

D.A. Crossley et al. (1992) observed the biodiversity of microarthropods in agricultural soils. He concluded that microarthropods participate in the complex food web of soil but their importance is seldom appreciated. In an another study, Vreeken-Buijs M.J. et al. (1994) described microarthropods biomass C–dynamics in the below ground food webs of two arable farming systems. In their study, the most abundant functional groups were omnivorus Collembola, omnivorus – non – cryptostigmatic mitres and predatory mites. He found no relation between the biomass of the microarthropods and their main food source. Next important work done by Coulson S.J. (1995) who postulated the low temperature performance of soil microarthropods at Nyalesund Spitsbergn. He concluded that the supercolling activity of these animals decreased rapidly on regaining activity in spring Starvation for 14 bands desiccation or a combination of both, resulted in little change in the means supercolling point of Collembola.

Heneghan L. et al. (1997) studied soil microarthropods community structure and litter decomposition dynamics: A study of tropical and temperate sites. In their study, half the litterbags were treated with naphthalene to reduce micro arthropod abundance. They found that the effect was minimal at the temperate site. In contrast, the effect of the fauna at the tropical sites was marked within months of the start of the experiment.

Vreeken-Buijs M.J. et al (1998) studied the relationship of soil microarthropods biomass with organic matter and pore size distribution in soils under different land use. They concluded that micro arthropod biomass was larger in sandy soil than in loamy and generally larger in meadows than in wheat fields.

In a study conducted by Heneghan L. et al. (1999), he stated that soil microarthropods contribution to decomposition dynamics tropical temperate comparison of a single substrate. They hypothesized that micro arthropod relation of the microbial population involved in leaf litter decomposition would be stronger in humid tropical forests.

In an another study conducted by Loranger G. et al. (2001) soil acidity explain altitudinal sequences in collembolan communities, density and local diversity of Collembola were observed to increase with soil acidity which can be explained by (i) physiological adaptations to acid soil inherited from Paleozoic times and (ii) more habitat and food resources when organic matter accumulates at the top of the soil profile. Steve H. Ferguson et al. (2002) observed about dynamics of springtails and mite population and the rule of density, dependence, predation and weather. An important study in 2003 done by Cassagne et al. who proved the relationship between Collembola, soil chemistry and humus types in forest stands (France). They found that Collembola seem to be linked more closely to the physiological structure of humus than to its chemical parameters.

In the same time De Deny Gerlinde B. et al. (2003) reported that soil invertebrate fauna enhance grassland succession and diversity. They concluded that soil microarthropods strongly affect the composition of natural vegetation. In a study conducted by Rusek Josef (2004) concluded the biodiversity of Collembola and their functional role in the ecosystem. Collembola play an important role in plant litter decomposition process and informing soil micro structure.

Concerning with Collembola, N. Lindberg and J. Bengtsson (2005) stated the population responses of Collembola and Oribatid mites after drought. They followed the population densities during a four year and sought correlation between the species drought responses and their ecological characteristics. However, among species showing negative population responses to drought species with large habitat width tended to recover faster after drought.

Ekelund flemming et al (2006) described the significance of soil collembolans, Protozoa and micro organisms and their interactions for soil fertility which a key concept in this discussion. Here they refer to the view presented by Madar et al. (2002) who suggested that fertile soils provide essential nutrients for crop plant growth, support a diverse and active biotic community exhibit a typical soil structure and allow for an undisturbed decomposition. An important aspect, at the same time given by Won Ti Choi et al (2006) who observed a modelling study of soil temperature and moisture effects on population dynamics of *Paronychicrus kimi* (Collembola: oncychiuridae). They suggested that soil moisture is a major limiting factor on field population of *P. Kimi.*

Tripathi G. et al. (2007) studied the mesofounal biodiversity and its importance in Thar desert. Their study supports that soil arthropods exhibited seasonal variation in their populations. There were two population peaks, one in February/March and other in August/September and faunal that the population showed a significant positive correlation with soil moisture, organic carbon and total nitrogen. Their study also suggest that the plantation may be done for improvement of physiochemical and biological health of soil on a sustainable basis in desert.

Recently, P. Schrooder (2008) focused on mesofauna and great importance for the turnover of organic matter and decomposition process in soil. Yoshida Tomohiro and Hijii Naoki (2008) studied the efficiency of extracting microarthropods from the canony litter in a Japanese. Cedar (Cryptomeria Japonica D. Don) plantation; a composition between washing and Tullegren methods. On the basis of the experiment, they suggested that the washing method is appropriate for the mite whereas Tullegren method is good for the Collembolan population.

In an another recent study, Steinaker Dilgo F. and Wilson Scott. D. (2008) proved scale and density dependent relationships among roots, mycorhizal fungi and Collembola in grassland and forest. They concluded that Collembola were significantly positively correlated with root production in forest and with both fungal and root production in grassland.

Materials and Method

MATERIALS AND METHOD

1. METHOD OF SAMPLING

The most commonly adopted method especially among the more recent workers involves the use of some kind of boring tool for the purpose of removing soil.

In the present investigation, a circular corer sampler based on the principle of O' Coner (1957) was used to avoid the casually of delicate soil fauna but a slight modification was made in the corer that it was not split throughout its length; instead the corer was single tube of 7cm internal diameter. The tube at its rear end bore a cutting edge. To facilitate its rotational movement, the upper end of the tube was fitted with a handle. In the sampler, ten iron rings were inserted to get an idea of the depth from which the sample was to be taken. An iron pusher was inserted throughout the length of the handle of the sampler. After each operation, the cutting edge was detached and the rings were pushed down through the pusher.

In the present study collection of mineral soil samples were taken from a depth of 5cms with the help of a corer as modified by Averbach and Crossley (1960). For vertical distribution studies, each sample obtained from 5cm depth.

2. EXTRACTION OF SOIL FAUNA

We have used a battery of 4 split funnels composed of three parts:

1. A bulb covered with a aluminium shade.
2. An aluminium vessel with a sieve at its base.
3. An aluminium funnel.

The vials containing 70% alcohol and few drops of glycerol were placed beneath each funnel. An illumination with electric bulb of 15 watts was provided to each funnel. The litter and soil in the rings were exposed for 36 - 72 hours. The intensity of illumination was controlled through a regulation.

The intensity of illumination was gradually increased with the time of exposure. Initially the intensity was low and after every 12 hours, intensity was gradually increased.

A stereoscopic binocular microscope was used for counting of insects and preserved in 70% alcohol. Some of the insects were mounted in polyvinyl alcohol which was prepared by the following method:

Polyvinyl alcohol	:	30gms
Distilled water	:	300c.c.

Both were boiled in water bath for complete dissolution, no this solution 10cc of glycerin and 10cc Lactic acid was added.

Larger insects and insect larvae were simply dehydrated by the usual methods and were mounted in DPX. Before mounting, the insects of darker colour were treated with cidar wood oil to impact transparency to these insects. The sides of the cover glasses were sealed with ordinary nail polish as to avoid evaporation of the mountant.

3. ANALYSIS OF EDAPHIC FACTORS

For this purpose, the soil samples were cored from the same plots from where the soil samples were collected for population analysis. Various edaphic factors such as temperature, soil moisture, hydrogen ion concentration, relative humidity, content of organic carbon, organic matter, phosphate and available nitrogen have been analysed by standard laboratory methods as discussed below:

i. Temperature:

Temperature of the soil was measured by directly inserting the soil thermometer into the soil upto 5cm.

ii. Relative Humidity:

Relative humidity of the surface of the soil has been determined with the help of a Dial hydrometer.

iii. Water Content:

The absolute content of water which has an impact on the activities an distribution of the animals generally exists in variable quantity rising to a maximum after heavy rain and falling rapidly during the hot months. For this reason, sample for the determination of water content were never collected immediately after heavy rains.

Content of water has been determined here by a method described by Dowdeswell (1959).

Procedure:

Soil samples after collection were kept in a tray for 24 hours for preliminary air drying. It was then crused in mortar and pastle and passed through fine sieve no. 80 to obtain fine powder of earth. Ten grams of this air dried fine earth was taken in an evaporating dish and kept in a hot air oven at about 105^{0}C for an hour. This was repeated at regular intervals until the weight become constant. The loss in weight expressed in percentage represented the moisture derived from both hygroscopic water some of the capillary water.

iv. Hydrogen ion concentration (pH):

To 100ml of double glass distilled water taken in a glass bottle 20gms of fine earth was added. The bottle was stoppered and shaken in a mechanical shaker for an hour; after which the solution was transferred to a glass beaker and its pH value was examined with the pH meter.

Before taking the reading of soil solution the instrument was standardized each time with a standard Backmen Buffer solution to avoid the instrumental error.

v. Organic Carbon estimation by Walkey – Black method:

Principle:

The soil is digested with potassium dichromate ($K_2Cr_2O_7$) and conc. H_2SO_4 making use of dilution of heat of conc. H_2SO_4. Excess dichromate is not reduced by ammonium sulphate ($FeSO_4$) $(NH_4)_2$ SO_4

$$K_2Cr_2O_7+4H_2SO_4 = K_2SO_4+Cr_2(SO_4)3+4H_2O+30$$

This nascent oxygen oxidizes carbon of the soil to carbondioxide.

Procedure:

Soil sample weighing 0.5gms were placed in a 500 ml conical flask after passing through 0.2mm (80 meshes/inch) non ferrous sieve 10ml of 1N $K_2Cr_2O_7$ solution was pipetted on to the soil, the two were mixed by swirling the flask, then 20ml of conc. H_2SO_4 were added and mixed by gentle rotation for 1 minute to ensure complete contact of the reagent with soil. The mixture was allowed to stand for 20-30 minutes.

A standardization blank (without soil) was run in the same way.

Back Titration:

The solution was diluted to 200ml with water 10ml of 85% H_3PO_4. 0.2gm of NaF and 30 drops of diphenylamine indicator was added. The solution was back titrated with 0.5N ferrous ammonium sulphate solution delivered from a burette. The solution in flask which turned turbid blue after the addition of the indicator, gradually assumed green colour and at the end point the colour became brilliant green after adding a drop of ammonium sulphate. The results were calculated by the equation given below:

$$\% \text{ OM} = 10(1\text{-}T/S) \times 1.34$$

S= Standardization blank titration, ml Ferrous solution

T= Sample titration, ml ferrous solution

a. The standard 1N $K_2Cr_2O_7$ was prepared by dissolving 49.04gm in water and the solution was diluted to one litre.

b. 0.5N solution of ferrous was prepared dissolution of 19.61gm of $Fe(NH_4)^2$ SO_4. $6H_2O$ in 8ml of water. To this solution 20CC of conc. H_2SO_4 was added. The solution was diluted to one litre.

vi. Phosphate:

Phosphate normally occurs in small quantities but none the less, their determination may be important in the study of a rapidly changing environment. In the present investigation molybdenum blue test as described by Dowdeswell (1959) was employed to estimate the phosphate content of the soil. The molybdenum blue test provided as ready means of colorimetric estimation involving minimum of time and apparatus.

Principle:

Orthophosphate and molybdate ions condensed in acidic solution to give molybdophosphoric acid which upon selected reduction produces a blue colour due to molybdenum blue of uncertain composition. The intensity of blue colour is proportional to the amount of phosphate initially incorporated in heteropoly complex which is thought to be formed by coordination of molybdate ions within phosphorous as the central coordinating atom, the oxygen of the molybdate radicals being substituted for PO_4.

$$H_3PO_4 + 12H_2MoO_4H_3P(MoO_{10})_4 + 12H_2O$$

Procedure:

To 100ml of soil extract taken in a conical flask, 1ml of molybdate sulphuric acid reagent and 5drops of 2.5% stannous chloride solution were added. It was mixed well and on being allowed to stand for 10 minutes. It resulted to blue colour. Similar treatment was followed with 100ml of standard phosphate solution (with 1ppm phosphorus).

Standard curve was plotted by measuring the optical densities of the series of gradual concentration derived from the original standard at a wave length 660nm in a spectro photometer (Bausch and Lamb). The optical density of the unknown material was compared against the standard curve and its concentration, phosphate was thus obtained being expressed as parts of phosphorous per million or as available phosphate as commonly used in agricultural practices.

vii. Available Nitrogen:

Available nitrogen occurs in small quantities which ultimately change into nitrate, their determination may be important in the study of a rapidly changing environment. In the present investigation Alkaline permanganate method was employed to estimate the available nitrogen in the soil.

Principle:

A known weight of the soil is mixed with excess of alkaline $KMNO_4$ solution and distilled Ammonia gas formed is absorbed in a known volume of standard acid excess of which is titrated with standard alkali using methyl red as the indicator.

Alkaline permanganate has been used as an extracting reagent for the characterisation of the nature of nitrogen in organic manures and this forms the standard AOAC procedure (AOAC 1960) for the estimation of active nitrogen.

This method, however, is the quickest of all other methods for the estimation of available nitrogen and has been found the work well even in Indian soils.

Procedure:

Take 20gm of the given soils sample in distillation flask and add 20ml of water. Now add 100ml of 0.32% $KMNO_4$ solution and 100ml of 2.5% sodium hydroxide solution and immediately fit it up in the distillation apparatus. Pipette out 20ml of 0.02N sulphuric acid in a conical flask and dip the end of the delivery tube in it. Distil ammonia gas from the distillation flask and collect about 30ml of the filtrate.

STATISTICAL ANALYSIS

Mean, standard deviation, SEM, correlation (r), Regression (y) and Analysis of variance (ANOVA) were calculated according to the formula described by S. Prasad (2003). Species diversity (H) and Evenness (v) were calculated by Shanon and Wiener diversity index (1949) and Evenness (Pielou, 1966) based on the following formula:

Shannon and Wiener diversity index (1949):

$$\bar{H} = -\sum_{i=1}^{N} P_i \log_2 P_i$$

Where,

$\bar{H}$ = species diversity

P_i = n_i/N is the probability of an individual to belong to a species.

N_i= no of individual in i^{th} species

N= Total number of individuals in samples.

S= Number of species.

Evenness (Pielou, 1966):-

$$J = H / H_{max}$$

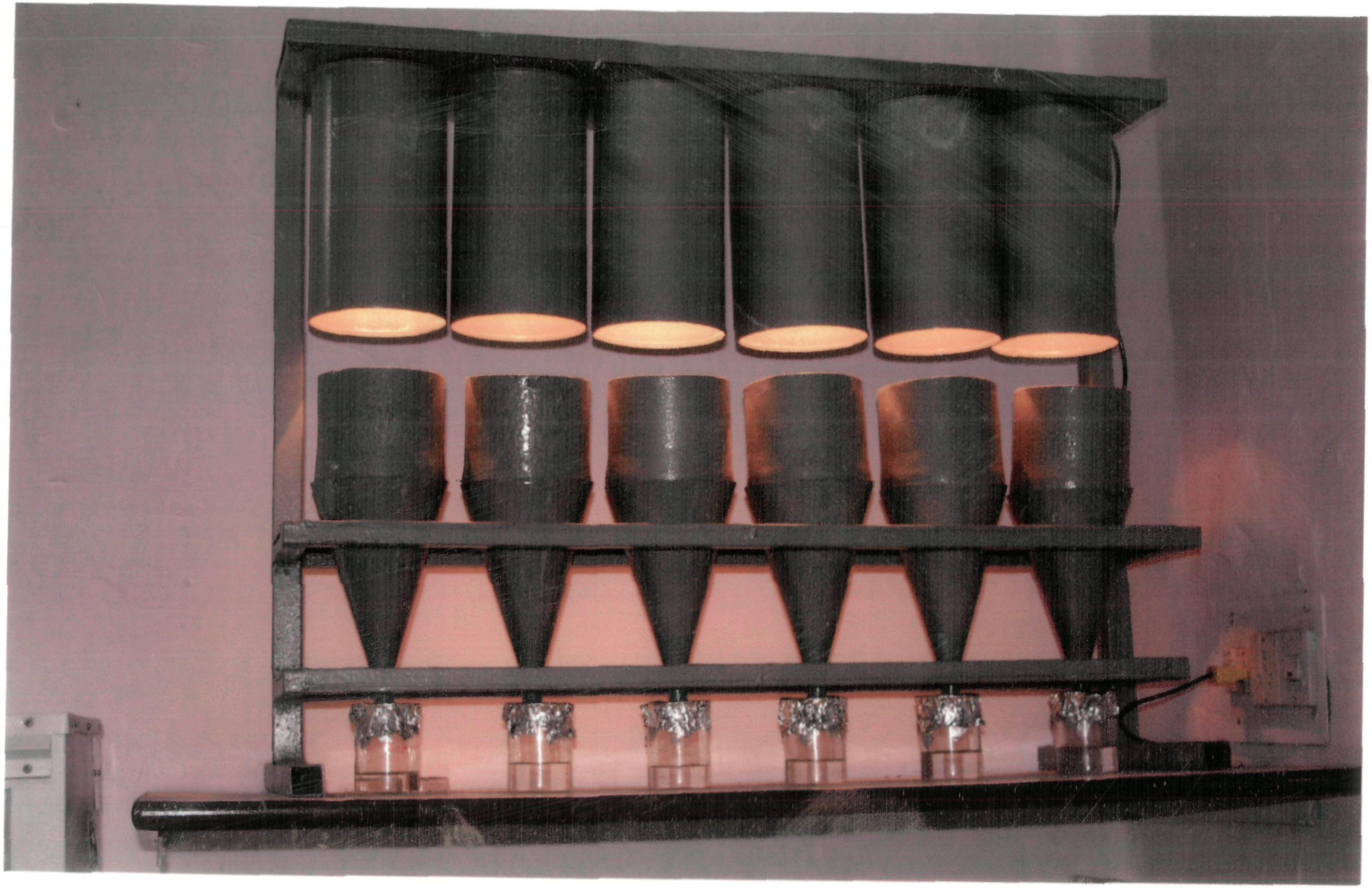
Where,

J= Eveness

$\bar{H}$= Diversity index described by Shannon wiener equation.

$H_{max}=\log_2 S$

S= Number of Species.



Picture: Tullegren Funnel

Sampling Site I (Grassland)

Sampling Site II (Teak Plantation)

Result

RESULT

A. Variation and seasonal fluctuation of physio-chemical factors at different sites.

The mechanical analysis of soil samples from both the sites revealed that the composition of the soil comprised sand, silt and clay in different proportions.

Monthly variation in different physio-chemical factors has been described sitewise below:

1. GRASSLAND SITE

i. Soil Temperature:

The maximum soil temperature was recorded in the month of August. It was $30^{0}C$. Minimum soil temperature was recorded in the month of January and it was $17^{0}C$.

ii. Soil Moisture:

Maximum soil moisture was recorded in the month of January. It was 4.71%. Minimum soil moisture was 0.80 in the month of May.

iii. Soil pH:

The range of soil pH did not show much variation throughout the year. It varied between 7.4 to 7.7

iv. Soil organic carbon:

The amount of organic carbon was found to be maximum in the month of January over the whole sampling period. It was 0.58% Minimum percentage of organic carbon varied during drier months as it was recorded.

v. Soil Phosphate:

The soil of grassland site had the phosphate content in a meagre amount. The phosphate content of the soil varied between 6.3 to 11.7 ppm. The amount of 'P' was lowest in the month of October and highest in the month of April.

vi. Soil potash:

Maximum potash content was recorded in the month of October. It was 264ppm whereas minimum potash content was 220ppm in the month of August.

vii. Soil Available Nitrogen:

The soil of grassland site contain available nitrogen varied between 226.8 to 256.2 ppm. Maximum available nitrogen was measure in the month of January. It was 256.2ppm while available nitrogen was minimum in the month of November and it was 226.8ppm.

2. TEAK PLANTATION SITE

i. Soil Temperature:

Maximum soil temperature was recorded in April and September and it was 34^{0}C. Minimum soil temperature was 15^{0}C in the month of January at this site.

ii. Soil Moisture:

Maximum soil moisture was recorded in the month of January during the sampling year. It was 4.27%. Minimum soil moisture content was recorded in the month of April and it was 0.30%.

iii. Soil pH:

The soil pH was more or less same as recorded in grassland site.

iv. Soil organic carbon:

Maximum amount of organic carbon was recorded in the month of March and minimum amount was recorded in July. It was 0.79% and 0.59% respectively.

v. Soil phosphate:

There was little variation in the maxima and minima of soil phosphate as in case of other site. The variation was between 9.0 to 10.0 ppm.

vi. Soil Potash:

Minimum soil potash was observed in January with 187ppm while minimum soil potash was recorded in the months of April and October with 242ppm.

vii. Soil Available Nitrogen:

The soil of this site contain maximum available nitrogen in July and it was 253.4ppm while minimum soil available nitrogen was rewarded in the month of Feb. and it was 226.8ppm.

B. Variation and seasonal fluctuation in the faunal population of the sites

1. GRASSLAND SITE

Mineral soil population

1. Insects: The insects sampled from the soil of this site belong to both the sub classes. The Pterygote population was represented both by adult and larval forms. In comparison to other insects Isopterans were numerous.

The Apterygote insects were dominated by Collembola and Diplura.

2. Acarina: The mite population of this site belonged to Prostigmate, Crytostigmata and Mesostigmata.

Seasonal Fluctuation:

The total number of insects and mites obtained from this site showed an irregular trend of fluctuation, during the sampling period ranging from March 08 to Feb. 09, among the adult pterygotes.

Isopterans were maximum in the month of November and minimum in October while totally absent in the months of March, July and August.

Dipterans were found maximum in May, August and September, where as minimum numbers were in March. They exhibited a gradual increase from March and attained a peak in August and September followed by gradual decline.

Coleopterans population was rich in June and it was poor in the month of January Coleopterans were not collected in the months of April, November and December.

Maximum population of Hymenoptera was record in December and minimum was in March and October while totally lacking in the months of April, June and September.

Apterygote population was followed by orders Collembola and Diplura. Among the collembolans their number was maximum in January and minimum in the month of September, same as in case of order-Diplura. Diplurans were nil in the months of March, April, June, September and November.

The mite population of this site exhibit a slight fluctuation. Maximum number of mites were collected in the month of October where as minimum number of mites were collected in the month of April Mite population found throughout the period of investigation.

2. TEAK PLANTATION SITE

Mineral Soil Population

1. Insects:

The pterygotan population was comparatively higher than that of the previous site. The pterygotan population was represented by the numbers of order Isoptera, Diptera, Coleoptera and Hymenoptera.

The Isopterans were collected in large number followed by few beetles and Ants in a meagre number.

The Apterygotan population was dominated by the numbers of order Collembola and Diplura.

2. Acarina:

The Acarina population was represented by all the three sub orders Prostigmate, Cryptostigmate and Mesostigmate. Mite population showed an irregular trend of population fluctuation.

3. Seasonal Fluctuation:

Teak plantation, in which trees of teak are regularly pruned. The ground floor is also tilled after 2-3 months. These operations do not allow the deposition of leaves.

Among the Isopteran population, their number was maxima in April and July while minima in December. Dipterans were found maximum in July and minimum in Feb. They were found throughout the year of investigation. Among the coleopterans their number increased with the onset of monsoon.

The Apterygote insects showed extremely high irregular fluctuation of the population collembolan population was maximum in February and minimum in the month of June and September. Whereas Diplurans are found in very little number except in the month of March.

The population of mites too showed a irregular fluctuation of population same as in case of Apterygote population mite population was rich in January and February months and poor in the month of June. They increase in number during monsoon.

Table 1(a). Mechanical analysis of soil at Grassland site.

Soil texture		
% of sand	% of silt	% of clay
64.8	26.0	9.2

Table 1(b). Mechanical analysis of soil at Teak Plantation site.

Soil texture		
% of sand	% of silt	% of clay
46.8	36.0	17.2

Table-2(a): Significance of population fluctuations of various insect groups as determined by ANOVA test during 2008-09 at Grassland site.

Order	Variation ratio F	
	Between Columns	Between rows
PTERYGOTE		
Isoptera	448.39	1.33
Diptera	109.05	3.53
Coleoptera	681.03	3.99
Hymenoptera	920.06	1.69
APTERYGOTE		
Collembola	931.64	1.64
Diplura	1048.99	2.71
ACARI	274.20	5.16

Table-2(b): Significance of population fluctuations of various insect groups as determined by ANOVA test during 2008-09 at teak plantation.

Order	Variation ratio F	
	Between Columns	Between rows
PTERYGOTE		
Isoptera	504.02	1.53
Diptera	259.02	2.64
Coleoptera	195.40	2.21
Hymenoptera	1165.25	1.12
APTERYGOTE		
Collembola	818.15	3.25
Diplura	1134.52	1.10
ACARI	720.32	3.84

Table-3(a): Relationship between different populations with edaphic factors during 2008-09 at grassland site.

Variables	Correlation	Slope	Intercept	Significance
PTERYGOTE				
Isoptera				
Soil Temperature	-0.540	-1.16	29.08	
Soil Moisture	0.012	0.006	2.26	
R.H.	-0.250	-1.60	72.15	
pH	-0.740	-0.024	7.63	S
Organic carbon	-0.200	0.003	0.52	
Organic matter	-0.230	-0.006	0.88	
Phosphate	0.002	0.001	8.70	
Potash	0.520	2.55	233.50	
Available Nitrogen	-0.580	-1.80	256.13	S
Diptera				
Soil Temperature	0.190	0.26	21.73	
Soil Moisture	-0.088	-0.028	2.66	
R.H.	0.360	1.51	46.93	
pH	-0.520	-0.011	7.70	
Organic carbon	-0.340	0.004	0.55	
Organic matter	-0.340	-0.006	0.94	
Phosphate	-0.510	-0.207	11.42	
Potash	-0.110	-0.34	246.54	
Available Nitrogen	-0.060	-0.13	251.85	
Coleoptera				
Soil Temperature	0.720	0.64	20.93	S
Soil Moisture	-0.052	-0.011	2.35	
R.H.	0.520	1.39	57.58	
pH	0.080	0.001	7.54	
Organic carbon	-0.020	0.0001	0.50	
Organic matter	0.010	0.0001	0.86	
Phosphate	-0.620	-0.159	9.75	S
Potash	-0.300	-0.61	246.05	
Available Nitrogen	0.270	0.35	247.79	
Hymenoptera				
Soil Temperature	-0.780	-0.37	27.99	S
Soil Moisture	0.173	0.0189	2.14	
R.H.	-0.380	-0.53	70.84	
pH	-0.450	0.0033	7.57	
Organic carbon	0.120	0.0005	0.50	
Organic matter	0.110	0.0006	0.85	
Phosphate	0.017	0.0023	8.67	
Potash	0.250	0.28	239.93	
Available Nitrogen	-0.240	-0.17	251.40	

Variables	Correlation	Slope	Intercept	Significance
APTERYGOTE				
Collembola				
Soil Temperature	-0.760	-0.23	27.86	S
Soil Moisture	0.611	0.043	1.80	S
R.H.	-0.230	-0.21	69.19	
pH	-0.300	0.0014	7.57	
Organic carbon	0.500	0.0012	0.49	
Organic matter	0.490	0.0019	0.84	
Phosphate	0.164	0.0144	8.53	
Potash	0.230	0.16	240.14	
Available Nitrogen	0.130	0.06	249.48	
Diplurans				
Soil Temperature	-0.580	-1.09	27.12	S
Soil Moisture	0.640	0.274	1.80	S
R.H.	-0.170	-0.97	68.53	
pH	-0.140	0.0041	7.56	
Organic carbon	0.580	0.008	0.49	S
Organic matter	0.590	0.014	0.83	S
Phosphate	0.017	0.009	8.68	
Potash	0.100	0.42	241.27	
Available Nitrogen	0.320	0.86	248.63	
ACARI				
Soil Temperature	0.080	0.14	24.23	
Soil Moisture	-0.273	-0.103	3.02	
R.H.	0.040	0.22	65.29	
Ph	-0.590	-0.015	7.66	S
Organic carbon	-0.210	0.0027	0.52	
Organic matter	-0.070	0.0015	0.87	
Phosphate	-0.674	-0.321	10.96	S
Potash	0.340	1.28	232.93	
Available Nitrogen	-0.320	-0.77	255.56	

Table-3(b): Relationship between different populations with edaphic factors during 2008-09 at teak plantation.

Variables	Correlation	Slope	Intercept	Significance
PTERYGOTE				
Isoptera				
Soil Temperature	-0.0004	-0.0010	25.211	
Soil Moisture	0.145	0.0904	2.066	
R.H.	0.045	0.363	65.957	
pH	0.207	0.0086	7.529	
Organic carbon	0.126	0.0027	0.498	
Organic matter	0.052	0.0018	0.853	
Phosphate	0.114	0.089	8.477	
Potash	-0.004	-0.024	242.059	
Available Nitrogen	0.292	1.152	247.349	
Diptera				
Soil Temperature	0.388	0.2671	20.957	
Soil Moisture	-0.093	-0.0146	2.517	
R.H.	0.644	1.324	45.753	S
pH	-0.291	-0.0030	7.598	
Organic carbon	-0.159	-0.0009	0.518	
Organic matter	-0.027	-0.0002	0.861	
Phosphate	-0.382	-0.076	9.896	
Potash	-0.333	-0.523	250.319	
Available Nitrogen	0.104	0.104	248.476	
Coleoptera				
Soil Temperature	-0.170	-0.2253	27.367	
Soil Moisture	0.231	0.0702	1.612	
R.H.	0.492	1.950	48.147	
pH	-0.359	-0.0072	7.619	
Organic carbon	0.034	0.0004	0.501	
Organic matter	0.037	0.0006	0.852	
Phosphate	-0.017	-0.007	8.755	
Potash	-0.113	-0.341	245.270	
Available Nitrogen	-0.024	-0.046	250.573	
Hymenoptera				
Soil Temperature	0.239	0.2301	24.767	
Soil Moisture	-0.234	-0.0517	2.383	
R.H.	-0.213	-0.612	68.007	
pH	0.533	0.0078	7.535	
Organic carbon	0.153	0.0011	0.502	
Organic matter	0.208	0.0025	0.853	
Phosphate	0.266	0.074	8.550	
Potash	0.064	0.141	241.730	
Available Nitrogen	0.079	0.110	249.923	

Variables	Correlation	Slope	Intercept	Significance
APTERYGOTE				
Collembola				
Soil Temperature	-0.583	-1.0792	27.996	
Soil Moisture	0.605	0.2562	1.622	S
R.H.	-0.187	-1.033	69.501	
pH	0.100	0.0028	7.543	
Organic carbon	0.667	0.0096	0.479	S
Organic matter	0.530	0.0123	0.826	
Phosphate	0.126	0.067	8.519	
Potash	0.227	0.956	239.530	
Available Nitrogen	0.337	0.903	247.801	
Diplurans				
Soil Temperature	0.254	0.1050	24.692	
Soil Moisture	-0.181	-0.0172	2.369	
R.H.	-0.137	-0.169	67.666	
pH	0.570	0.0036	7.532	
Organic carbon	0.176	0.0006	0.501	
Organic matter	0.221	0.0012	0.852	
Phosphate	0.316	0.038	8.507	
Potash	-0.023	-0.022	242.108	
Available Nitrogen	0.112	0.067	249.805	
ACARI				
Soil Temperature	-0.518	-0.2842	28.122	
Soil Moisture	0.785	0.0986	1.273	S
R.H.	0.118	0.194	64.850	
Ph	0.042	0.0003	7.546	
Organic carbon	0.469	0.0020	0.484	
Organic matter	0.335	0.0023	0.834	
Phosphate	0.146	0.023	8.455	
Potash	-0.172	-0.215	244.202	
Available Nitrogen	0.321	0.255	247.520	

Table-4(a): Monthly variation in species diversity of different insectan groups represented by Shannon Wiener diversity index (H) and Evenness (E) during 2008-09 at grassland site.

Diversity / Months	Diversity index (H)	Evenness (E)
Mar.08	1.19	0.48
Apr.	1.22	0.36
May	1.70	0.45
Jun.	1.45	0.38
Jul.	1.34	0.37
Aug.	1.52	0.41
Sep.	1.36	0.37
Oct.	1.55	0.40
Nov.	1.58	0.39
Dec.	1.52	0.34
Jan.09	1.42	0.30
Feb.	1.72	0.44

Table-4(b): Monthly variation in species diversity of different insectan groups represented by Shannon Wiener diversity index (H) and Evenness (E) during 2008-09 at teak plantation.

Diversity / Months	Diversity index (H)	Evenness (E)
Mar.08	1.21	0.28
Apr.	1.16	0.31
May	1.09	0.38
Jun.	0.87	0.23
Jul.	1.23	0.32
Aug.	1.39	0.33
Sep.	1.46	0.40
Oct.	1.77	0.45
Nov.	1.28	0.37
Dec.	1.35	0.36
Jan.09	1.36	0.34
Feb.	1.43	0.36

Table- 5: Climatological Data of Aligarh during 2008-09

Months	Temperature (°C)			Relative humidity (%)			Total rainfall (mm)
	Minimum	Maximum	Average	Minimum	Maximum	Average	
Mar.08	18.0	42.8	30.4	40	86	63.0	24.0
Apr.	18.5	43.5	31.0	37	86	61.5	117.8
May	20.5	44.0	32.3	36	94	65.0	184.8
Jun.	23.5	39.0	31.3	51	92	71.5	317.4
Jul.	24.4	36.5	30.5	62	100	81.0	240.0
Aug.	24.0	25.5	29.8	62	97	79.5	122.6
Sep.	21.0	37.5	29.3	48	95	71.5	–
Oct.	17.4	31.0	24.2	47	92	69.5	18.0
Nov.	9.8	23.5	16.6	45	91	68.0	–
Dec.	4.5	19.0	11.7	43	90	66.5	–
Jan.09	4.2	20.5	12.4	38	89	63.5	10.0
Feb.	11.8	26.0	18.9	49	91	70.0	–

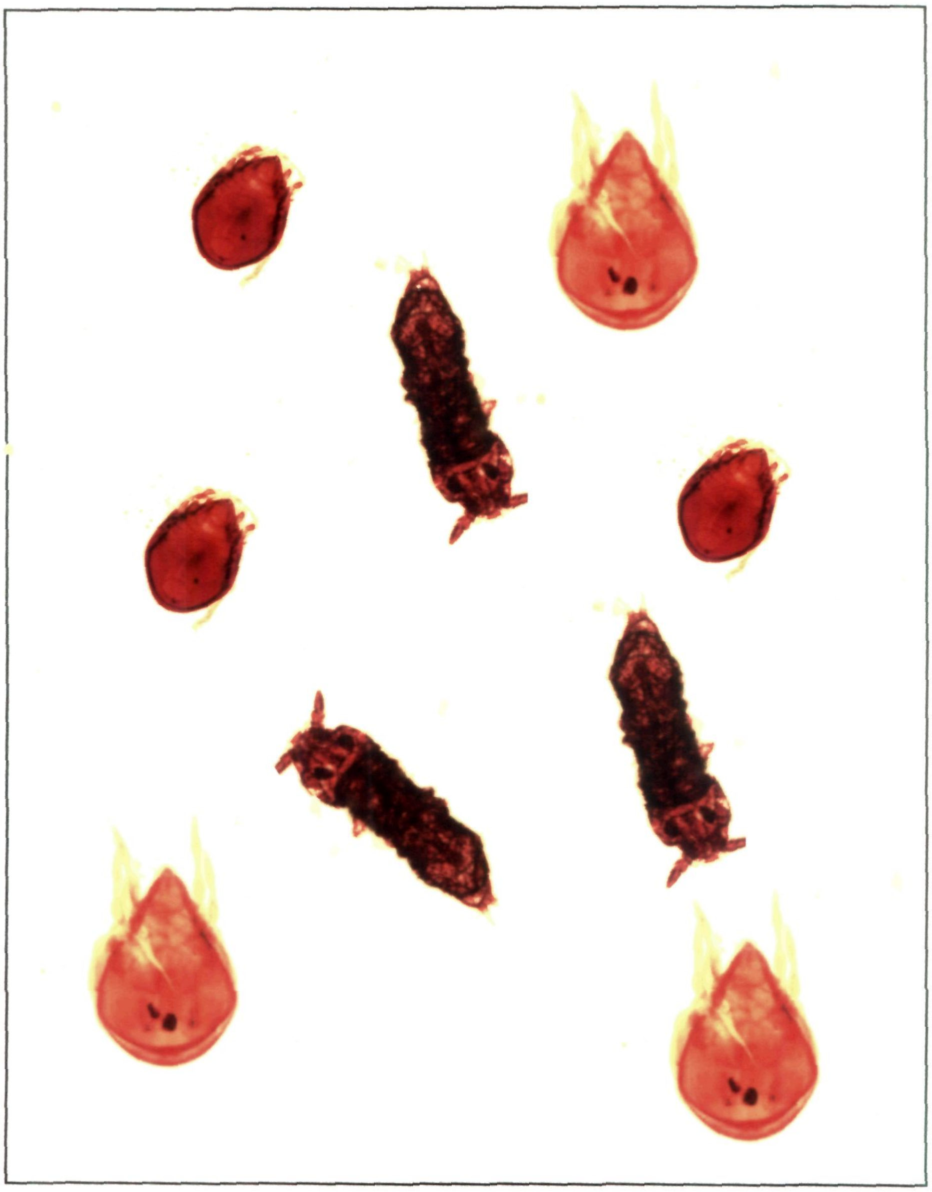
Table 6(a): Seasonal variation in edaphic factors during 2008-09 at Grassland site.

Months	Temperature (°C)	Moisture (%)	R.H. (%)	pH	Organic carbon (%)	Organic matter (%)	Phosphate (ppm)	Potash (ppm)	Available nitrogen (ppm)
Mar.08	29.0	1.62	59	7.7	0.53	0.91	10.4	240	253.4
Apr.	23.0	1.42	59	7.6	0.48	0.82	11.7	242	252.0
May	30.0	0.80	47	7.6	0.45	0.77	8.5	238	250.6
Jun.	29.0	2.45	92	7.5	0.52	0.89	7.2	233	253.4
Jul.	29.5	2.88	78	7.6	0.52	0.89	7.2	231	252.0
Aug.	30.5	2.88	92	7.6	0.48	0.82	9.0	220	254.8
Sep.	29.0	2.24	85	7.5	0.52	0.89	8.7	245	250.6
Oct.	27.0	1.11	54	7.5	0.49	0.84	6.3	264	249.2
Nov.	23.0	1.52	54	7.4	0.43	0.74	7.5	260	226.8
Dec.	17.5	1.62	56	7.5	0.51	0.87	9.0	242	250.6
Jan.09	17.0	4.71	63	7.5	0.58	0.99	9.0	249	256.2
Feb.	18.0	4.16	63	7.6	0.54	0.86	9.8	240	252.0

Table 6(b): Seasonal variation in edaphic factors during 2008-09 at teak plantation site.

Months	Temperature (°C)	Moisture (%)	R.H. (%)	pH	Organic carbon (%)	Organic matter (%)	Phosphate (ppm)	Potash (ppm)	Available nitrogen (ppm)
Mar.08	30.0	0.67	32	7.5	0.79	1.36	9.5	241.0	231.0
Apr.	34.0	0.30	31	7.5	0.78	1.34	10.8	242.0	252.0
May	30.0	0.81	32	7.6	0.66	1.13	10.4	229.0	233.8
Jun.	28.5	2.56	45	7.5	0.69	1.18	9.0	231.0	250.6
Jul.	29.0	3.30	81	7.7	0.59	1.01	10.8	198.0	253.4
Aug.	29.0	3.30	91	7.7	0.68	1.17	10.4	238.0	247.8
Sep.	34.0	1.21	63	7.6	0.63	1.08	9.0	231.5	249.2
Oct.	28.0	3.50	59	7.4	0.72	1.24	9.2	242.0	250.6
Nov.	24.0	3.73	45	7.5	0.64	1.10	9.5	229.0	252.0
Dec.	20.0	3.84	73	7.5	0.62	1.06	10.0	230.0	251.4
Jan.09	15.0	4.27	65	7.6	0.73	1.25	10.8	187.0	232.4
Feb.	18.0	4.21	77	7.4	0.71	1.22	10.2	195.0	226.8

Picture: Pterygote Insects



Picture: Apterygote Insects (Collembola and Mites)

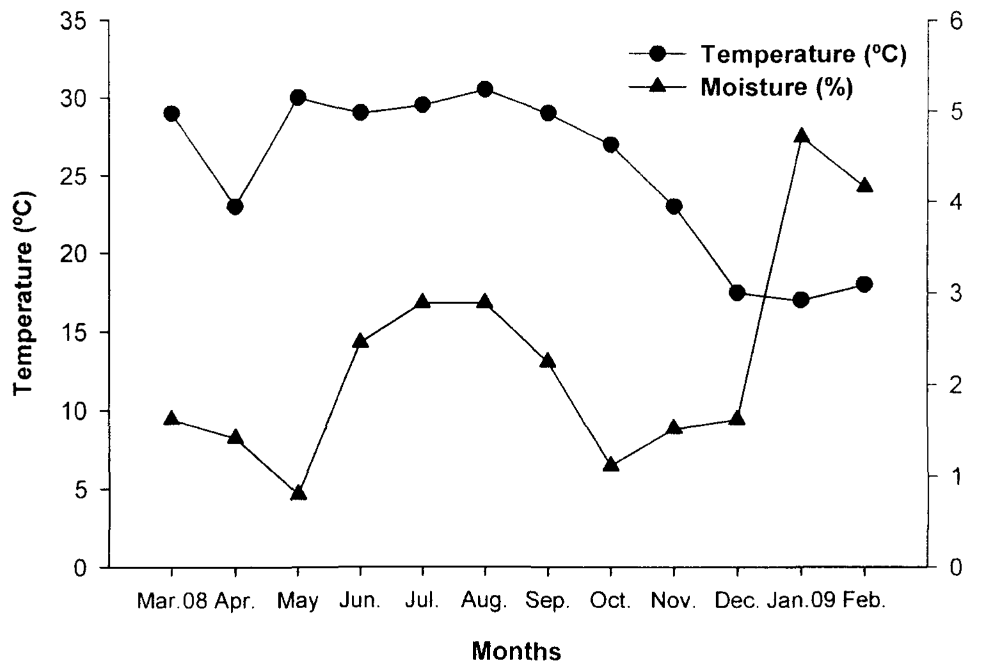


Fig. 1(a) Correlation between soil temperature and soil moisture at grassland site.

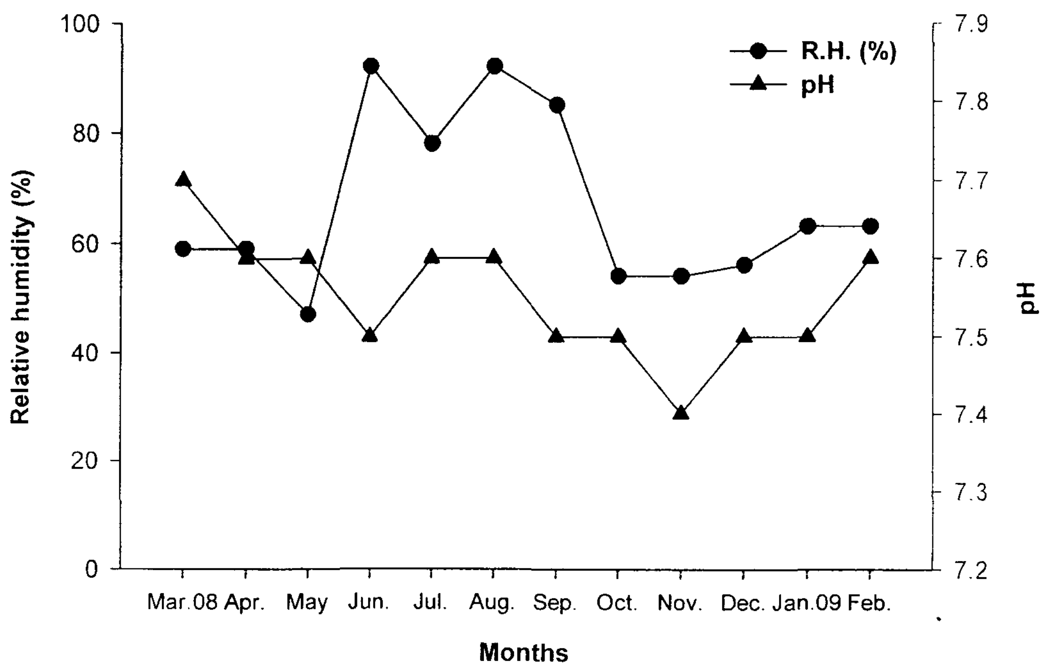


Fig.1(b) Correlation between relative humidity and pH at grassland site.

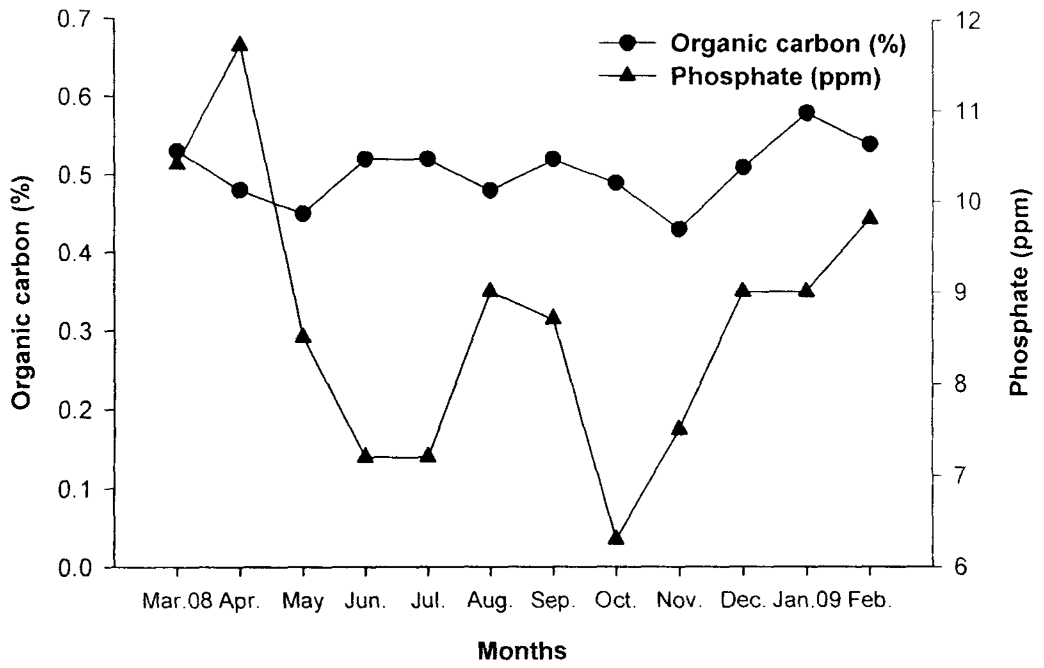


Fig.1(c) Correlation between organic carbon and phosphate at grassland site.

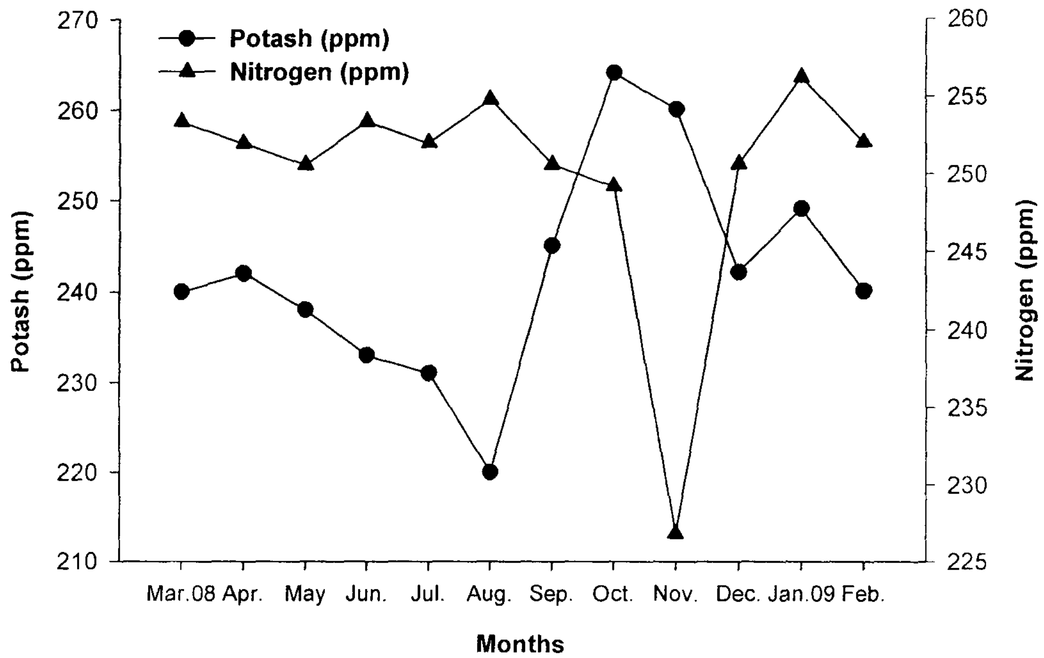


Fig.1(d) Correlation between potash and nitrogen at grassland site.

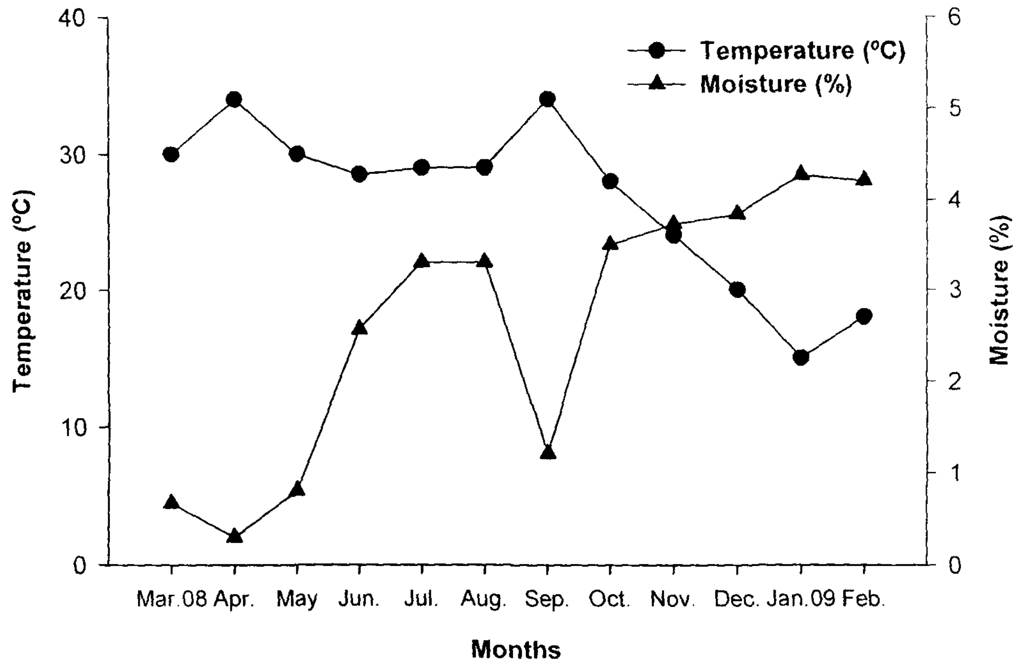


Fig.1(e) Correlation between soil temperature and soil moisture at teak plantation.

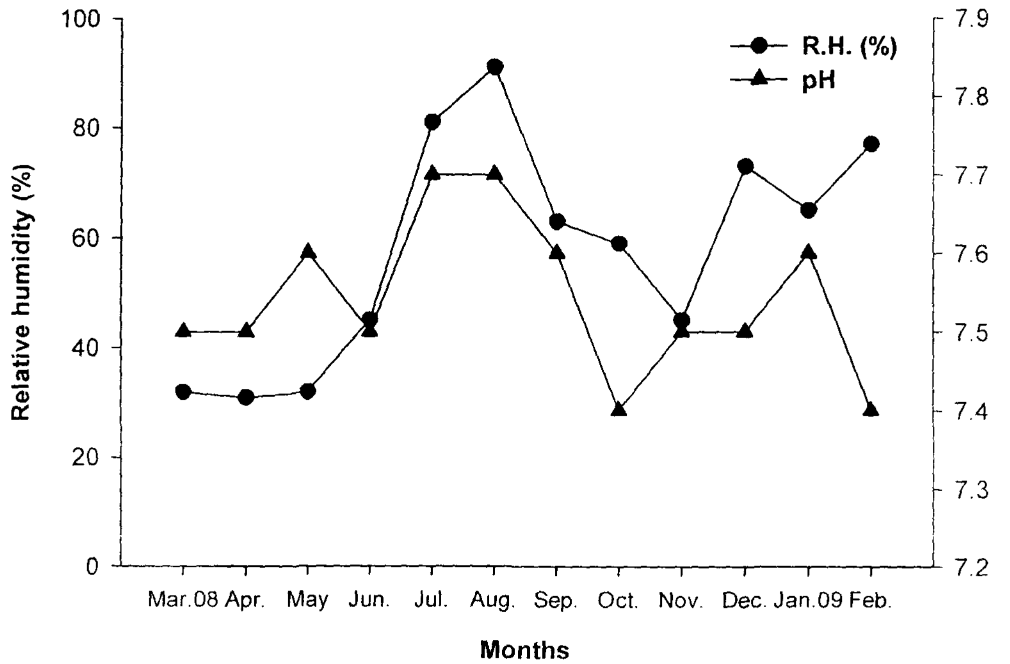


Fig.1(f) Correlation between relative humidity and pH at teak plantation.

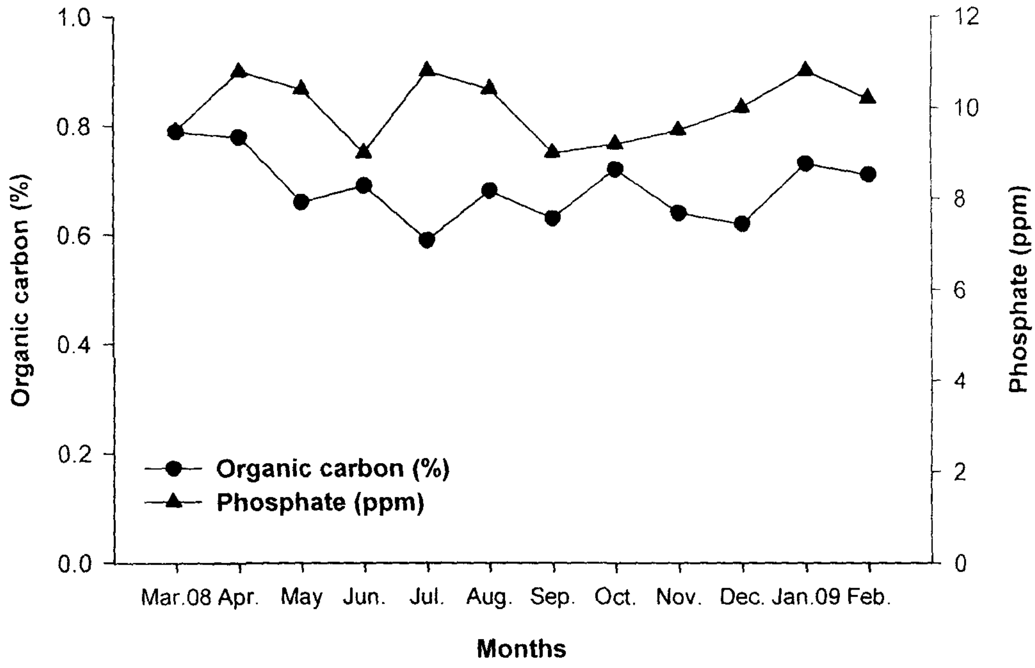


Fig.1(g) Correlation between organic carbon and phosphate at teak plantation.

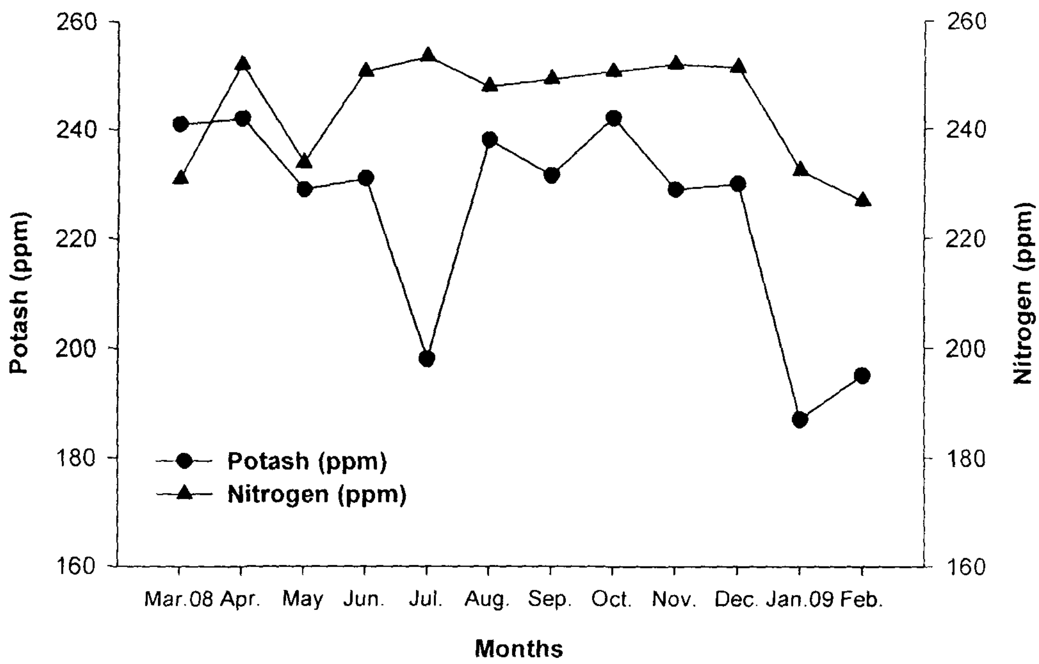


Fig.1(h) Correlation between potash and nitrogen at teak plantation.

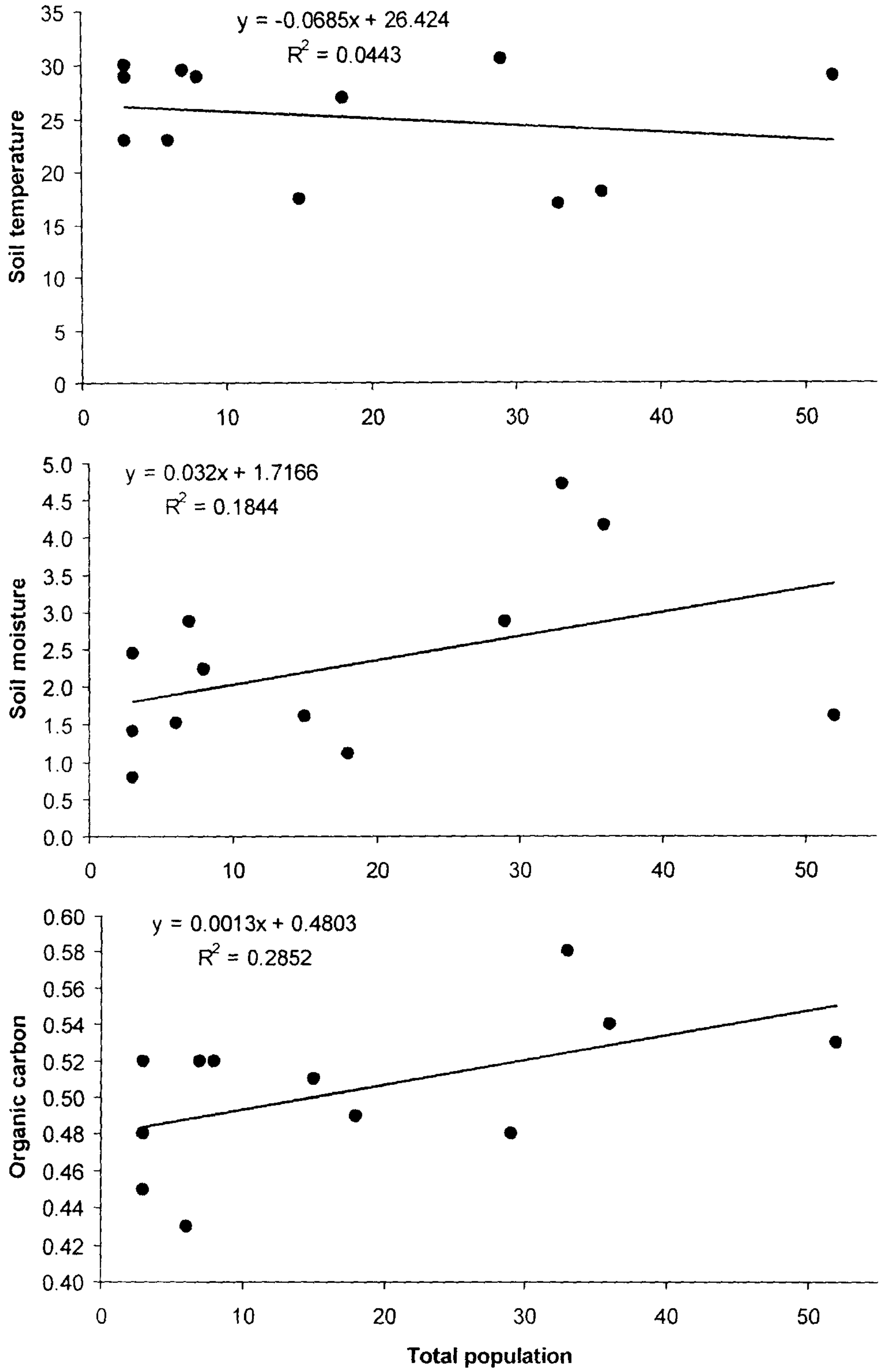


Fig.2 (a) Regression analysis of total population of insectan of mineral soils with (a) soil temperature, (b) soil moisutre and (c) organic carbon at grassland site

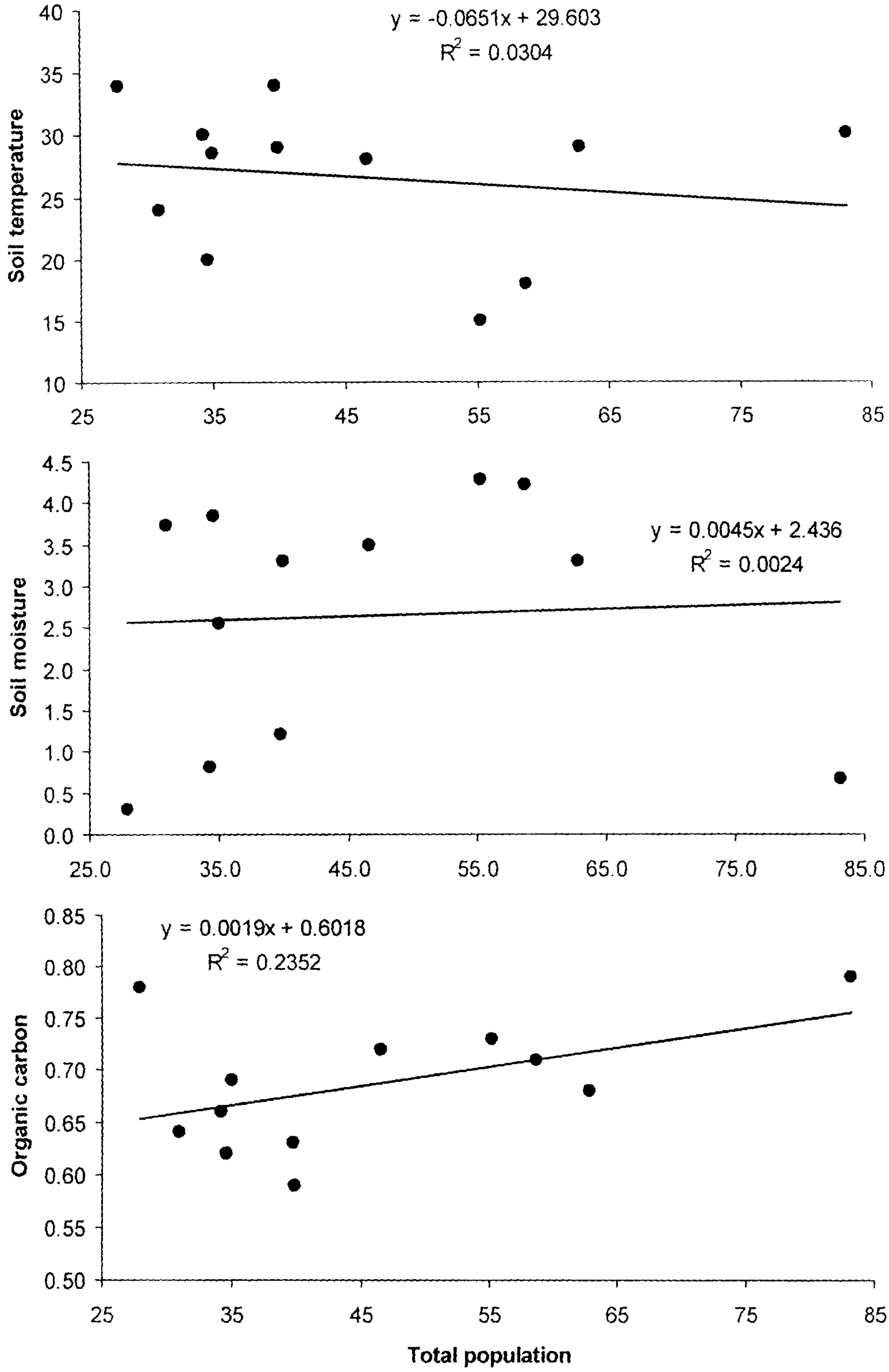


Fig.2 (b) Regression analysis of total population of insectan of mineral soils with (a) soil temperature, (b) soil moisutre and (c) organic carbon at teak plantation

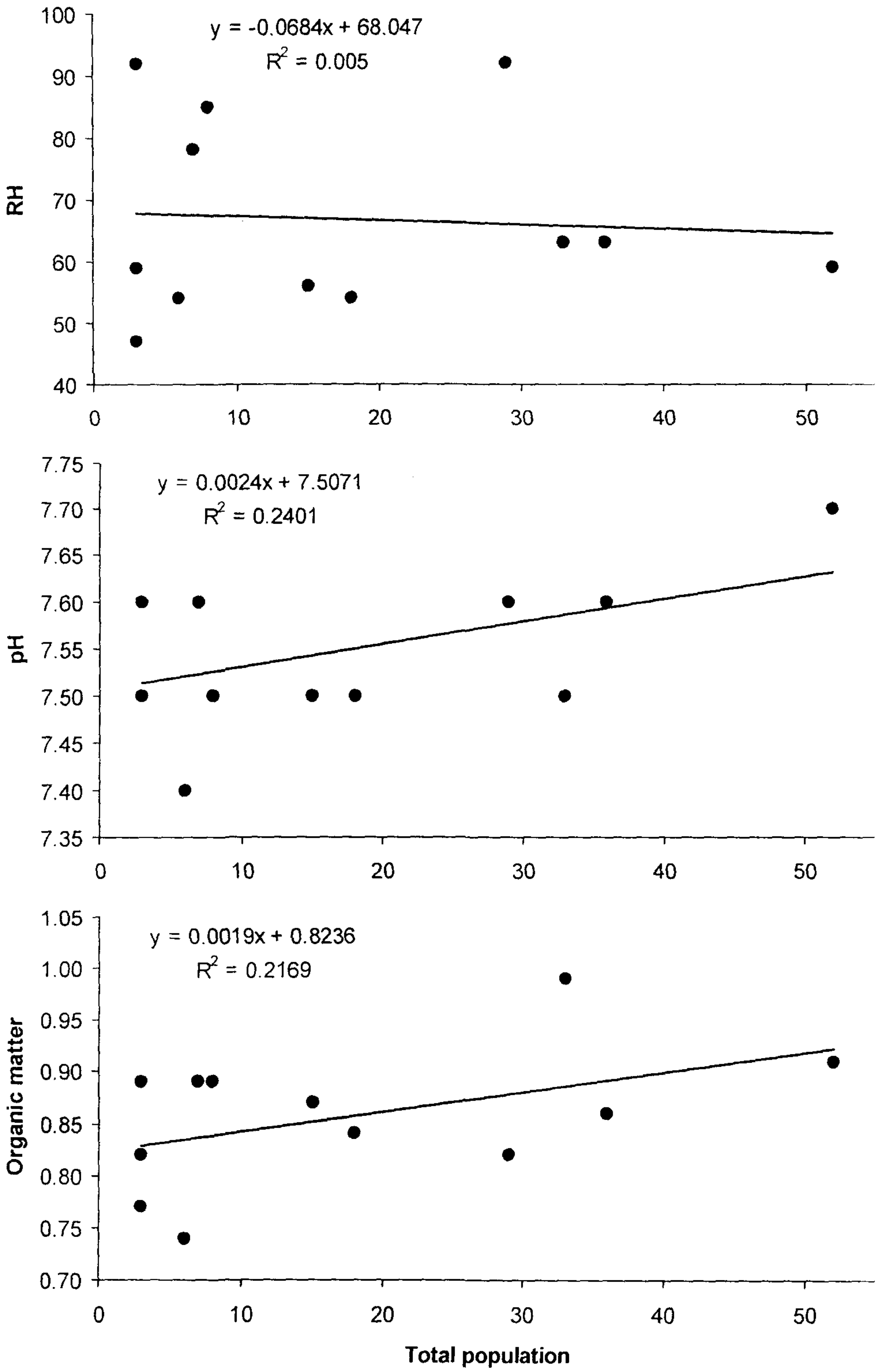


Fig.2 (c) Regression analysis of total population of insectan of mineral soils with (a) RH factor, (b) pH and (c) organic matter at grassland site

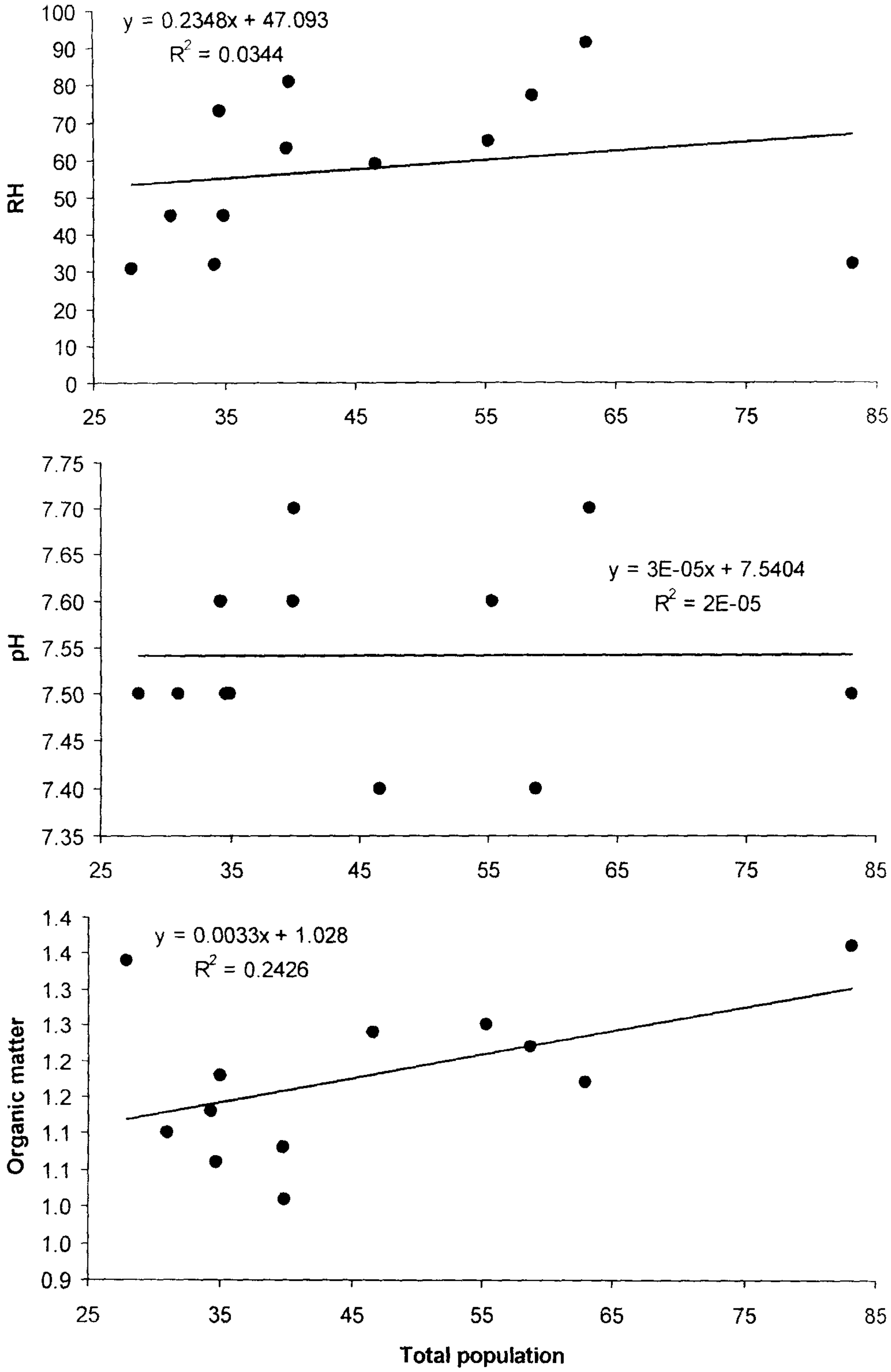


Fig.2 (d) Regression analysis of total population of insectan of mineral soils with (a) RH factor, (b) pH and (c) organic matter at teak plantation site

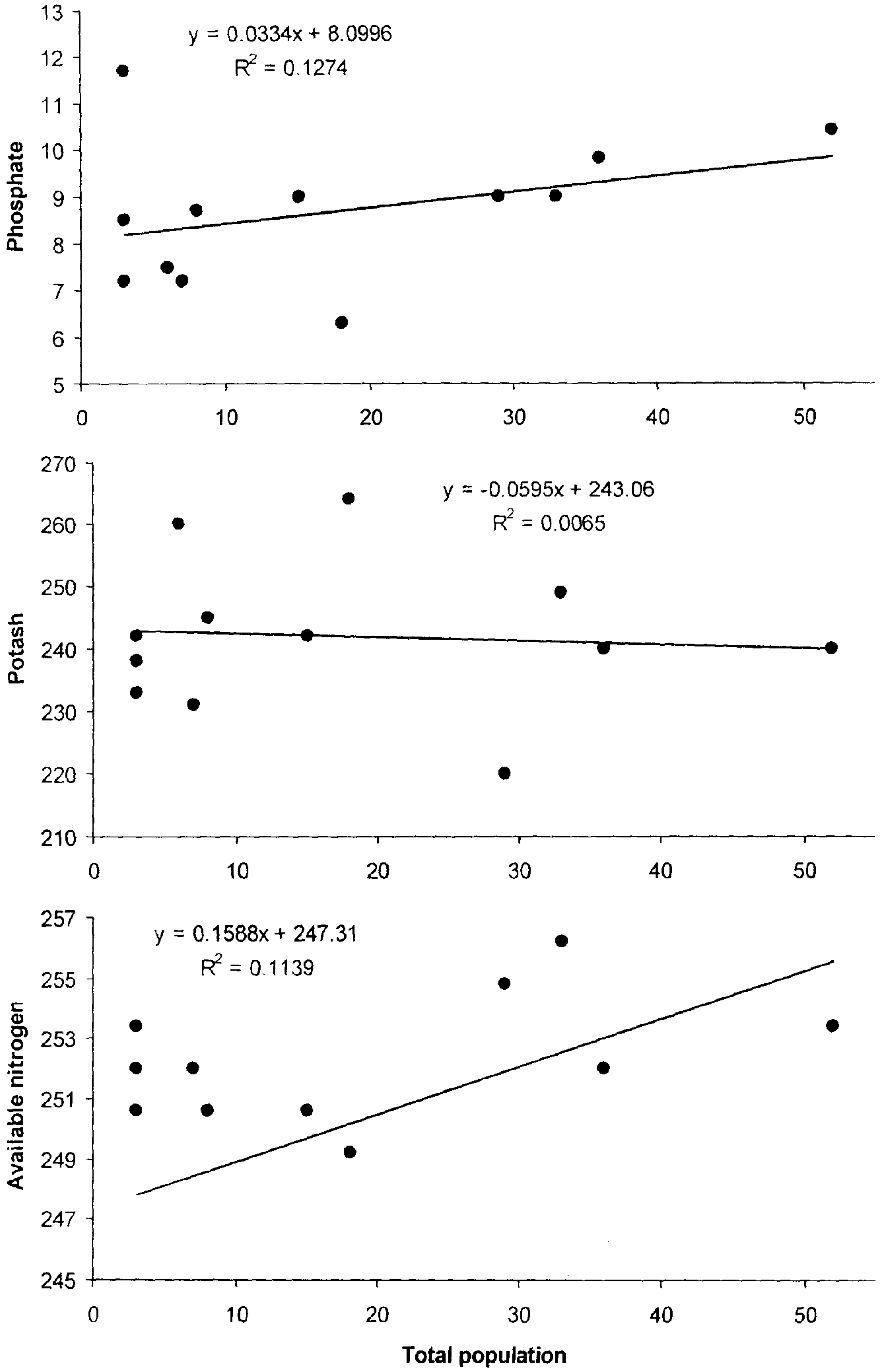


Fig.2 (e) Regression analysis of total population of insectan of mineral soils with (a) phosphate, (b) potash and (c) available nitrogen at grassland site

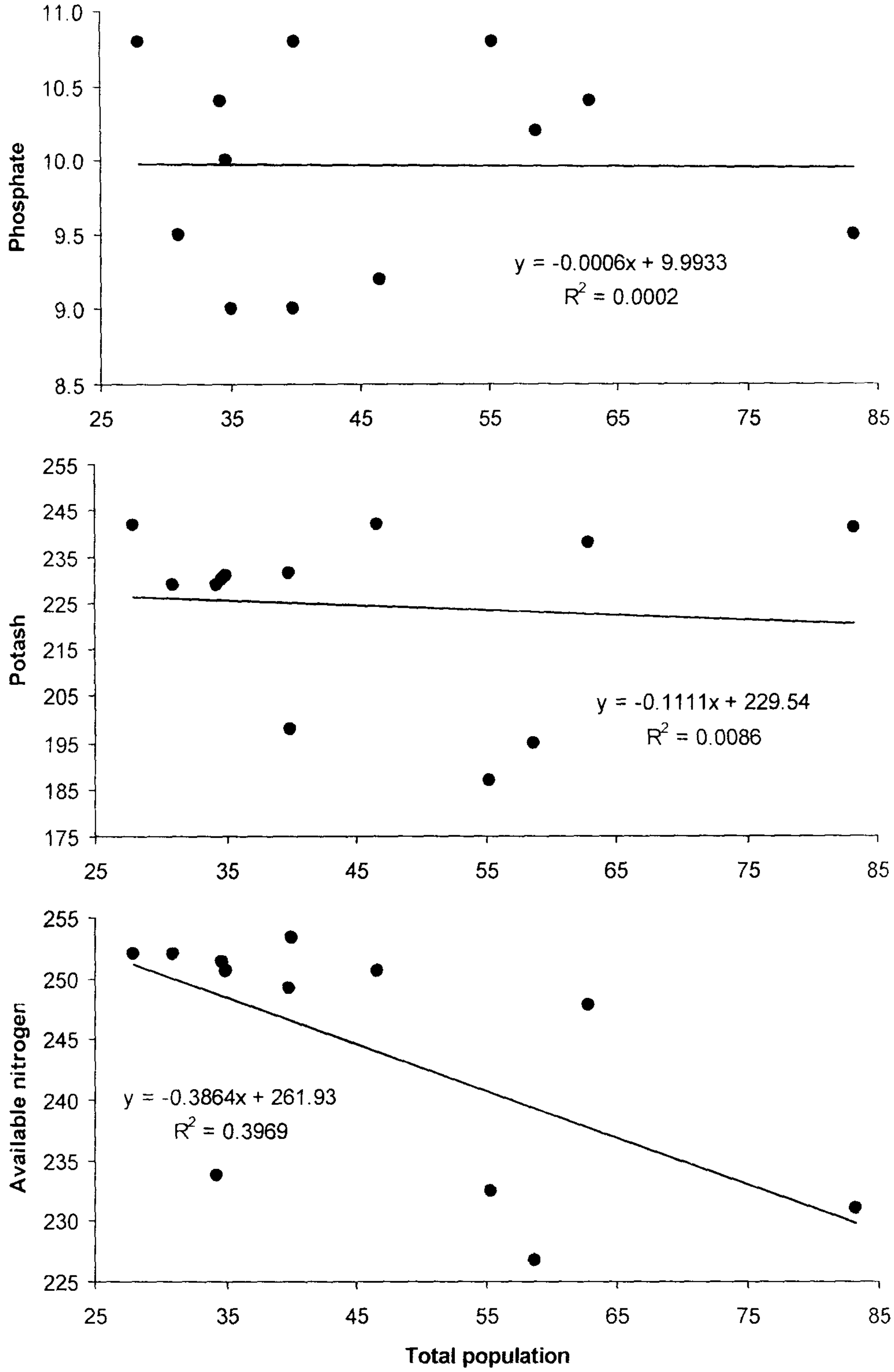


Fig.2 (f) Regression analysis of total population of insectan of mineral soils with (a) phosphate, (b) potash and (c) available nitrogen at teak plantation

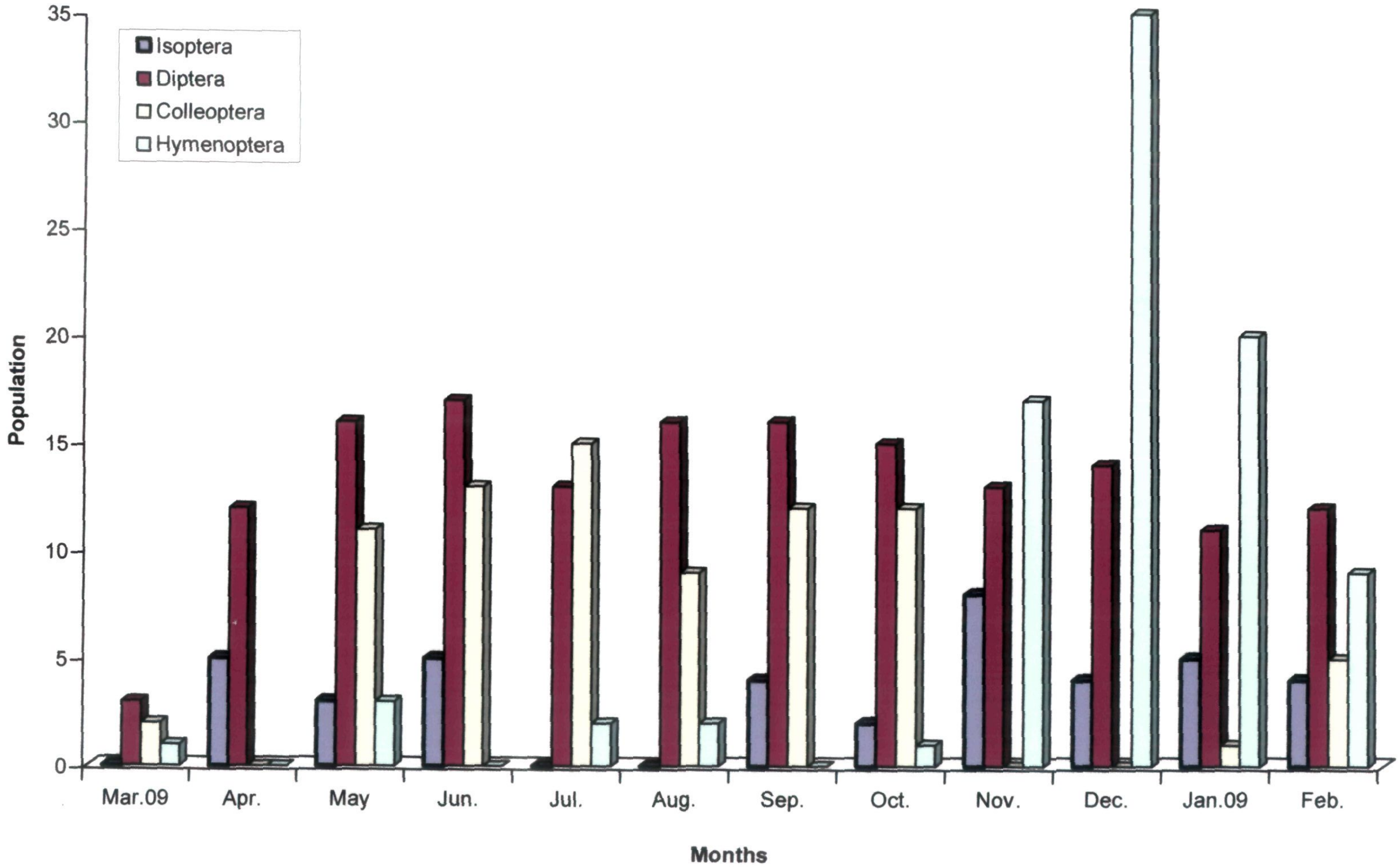


Fig-3(a) Population fluctuation of Pterygote insects from the site during 2008-09 at grassland site.

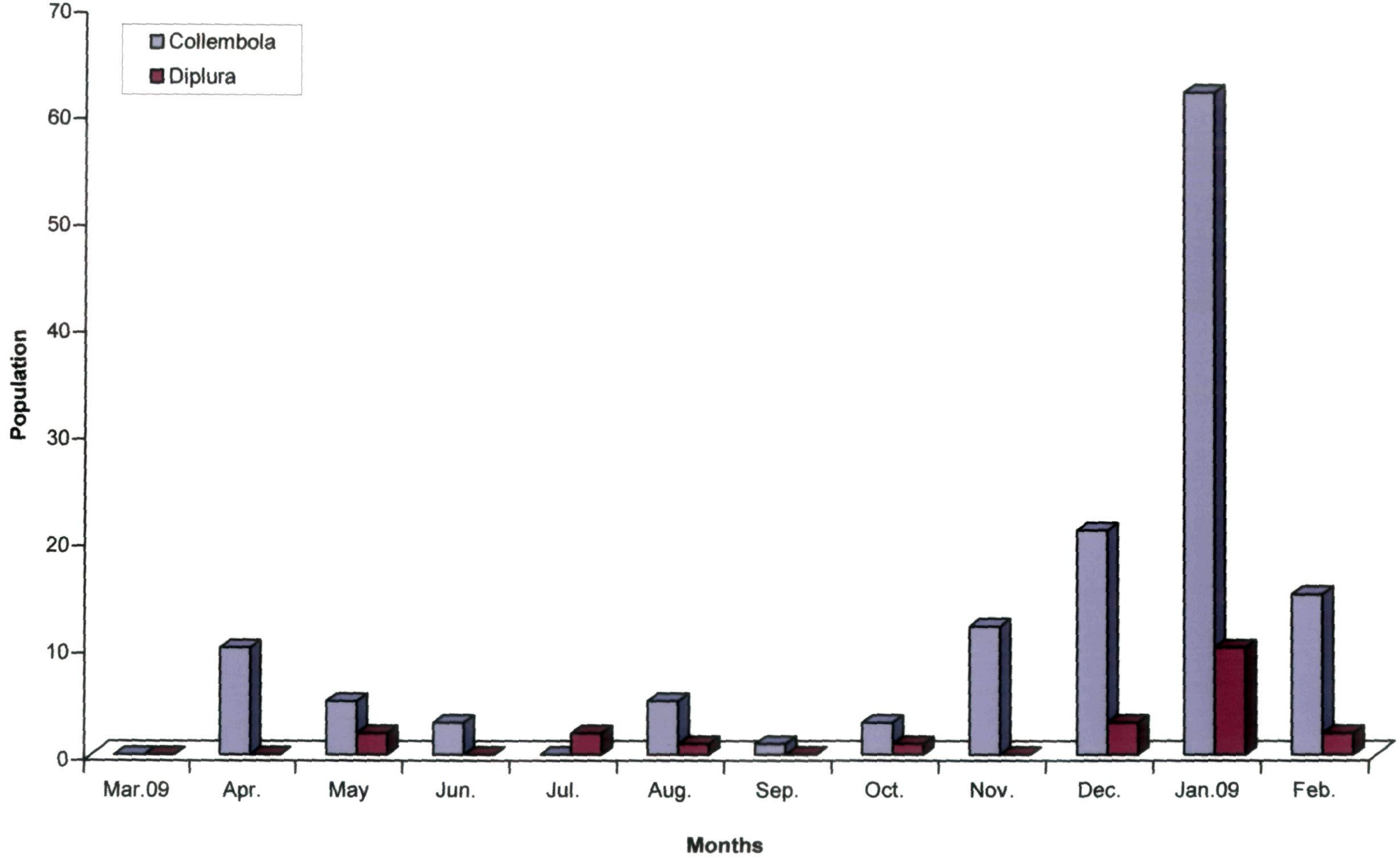


Fig-3(b) Population fluctuation of Apterygote insects from the site during 2008-09 at grassland site.

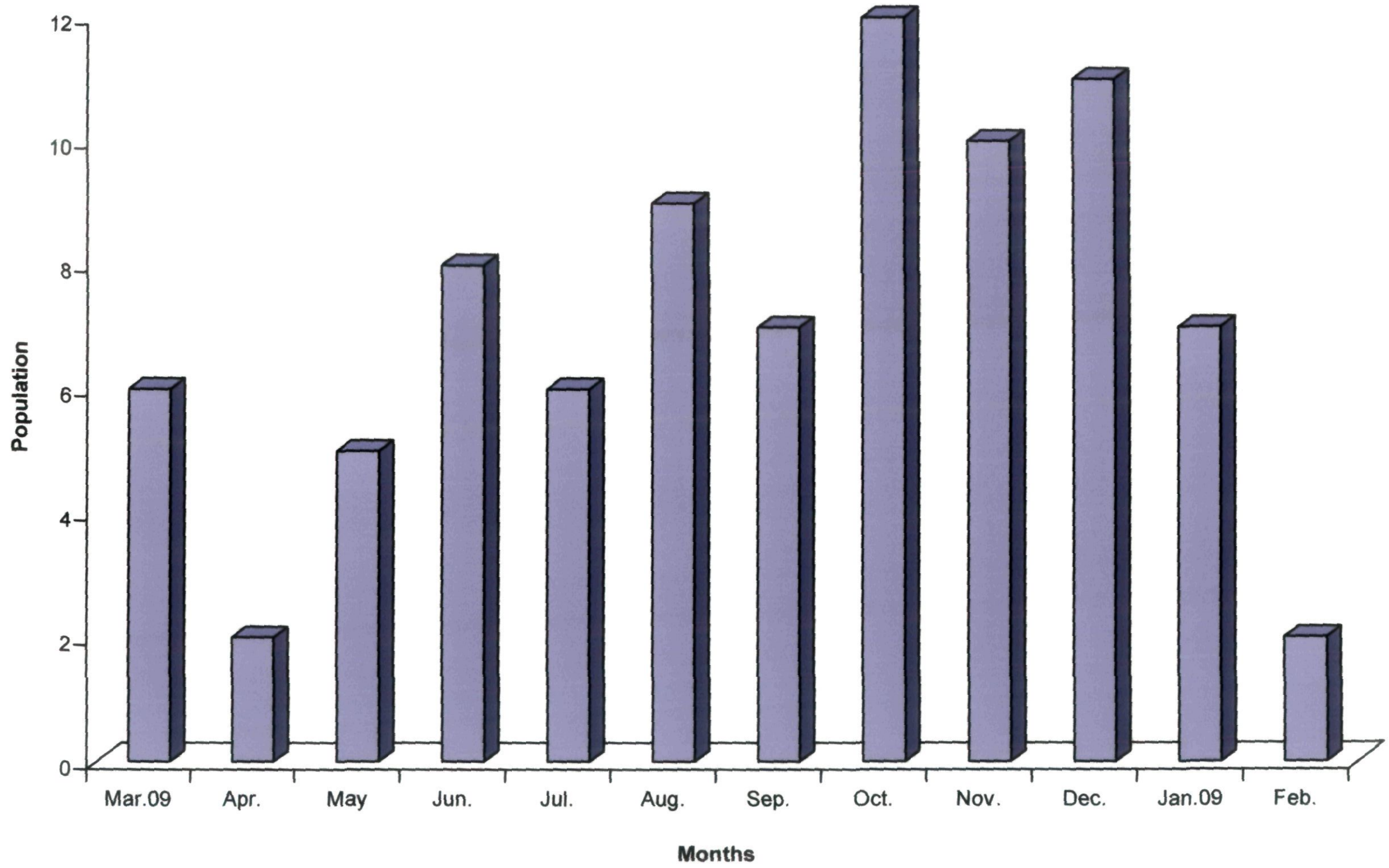


Fig-3(c) Population fluctuation of Acari insects from the site during 2008-09 at grassland site.

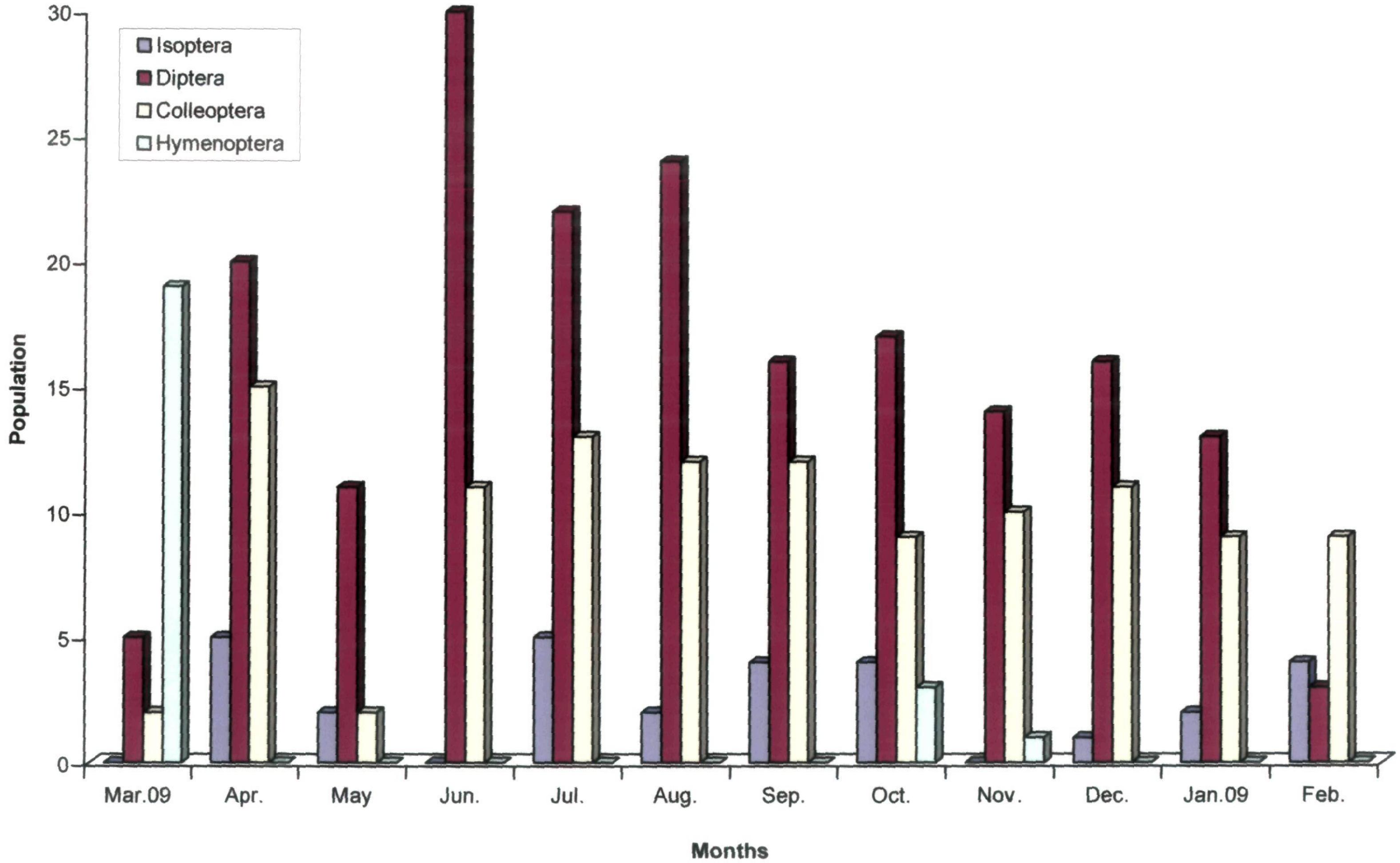


Fig-4(a) Population fluctuation of Pterygote insects from the site during 2008-09 at teak plantation.

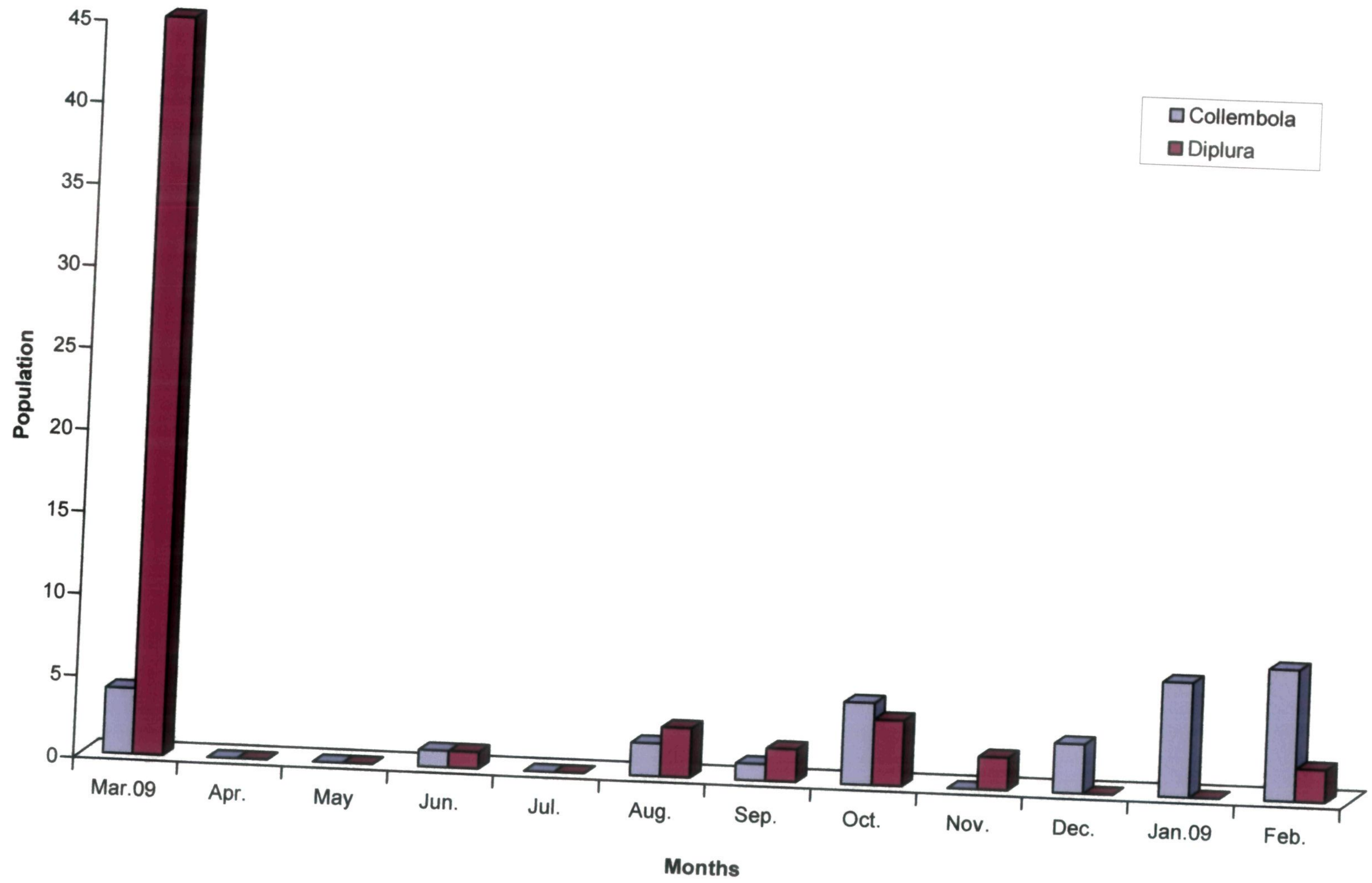


Fig-4(b) Population fluctuation of Apterygote insects from the site during 2008-09 at teak plantation.

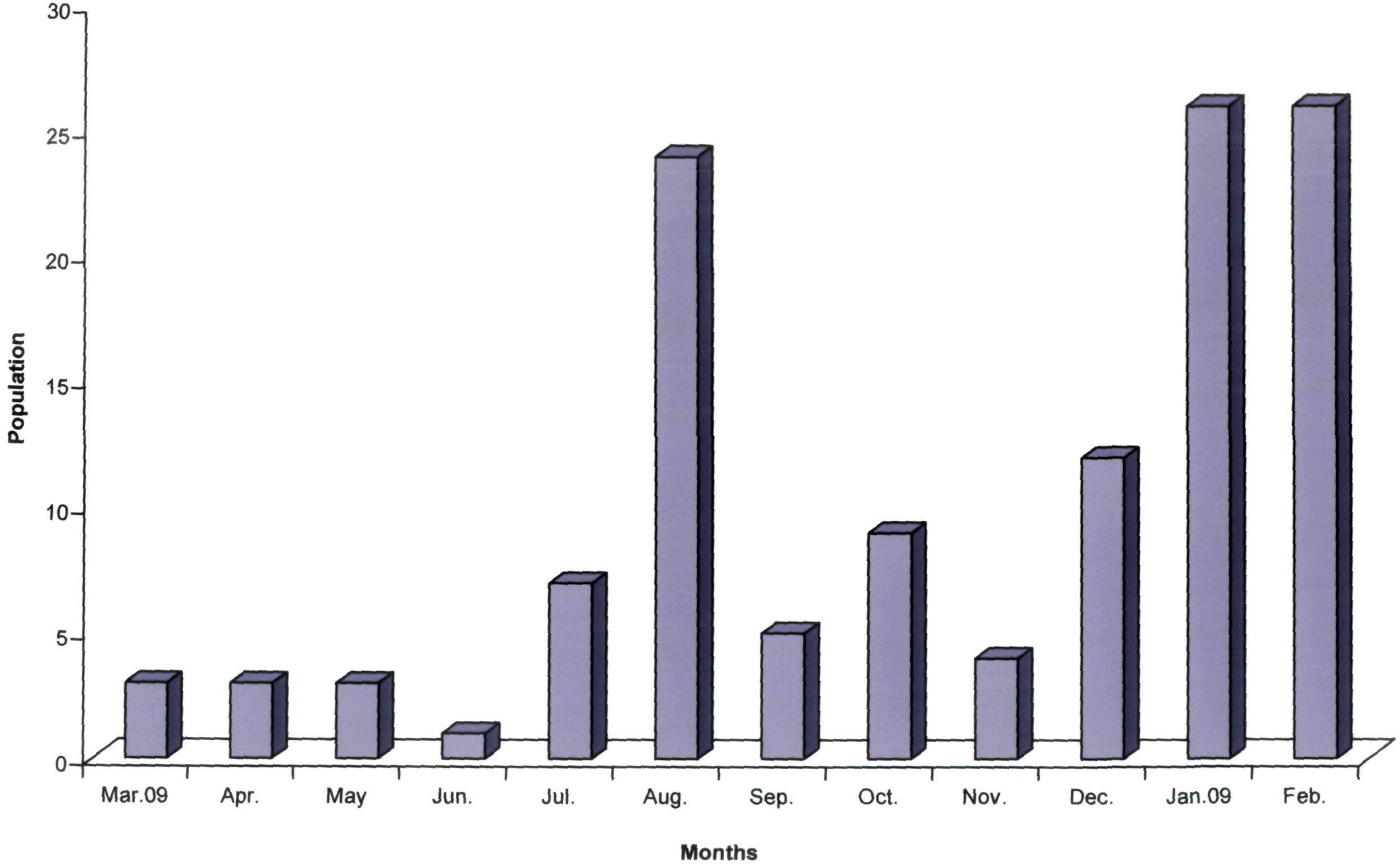


Fig-4(c) Population fluctuation of Acari insects from the site during 2008-09 at teak plantation.

Discussion

DISCUSSION

1. Grassland Site:

The work carried out in a stipulated period for the assessment of circannual variation and interrelationship of abiotic factor with the soil insects in two different sites gave interesting results. The samples collected from the grassland yielded insects and mites. The total number of insects and mites showed an irregular trend of fluctuation during the sampling period. This site was under the supervision of lands and garden department of the university, hence it received a regular look after by the gardners. This site also received regular ploughing, manuring and weeding. The plantation done in the beds was also seasonal. The lawn grass was also trimed mechanically by moving machine.

Secondly as a part of the campus, this place is used by students and passer bys regularly. Tree shade of huge trees are very less of only Goldmohar and Ashoka trees are planted on the road side. Therefore, there is no litter deposition either on the flower beds on the lawns.

The pterygote insection population was diversified and represented by order Isopteran, Diptera, Coleoptera and Hymenoptera. The occurance of these orders is inconsistent.

Isopterans were collected in maximum number in the month of November when the soil temperature was 23^{0}C. Soil moisture was also moderate 1.52%. The soil was slightly on higher acidic side (7.4). The soil temperature has a direct effect on the population of these insects.

Dipteran population was maximum in May, August and September, when the atmospheric conditions and soil conditions favored their life cycle significantly and positively. Regarding the coleopterans larval forms along with adults were also collected in the month of June when high atmospheric temperature, dry soil conditions and high humidity favours their life cycle.

When the organic carbon and available nitrogen was lowest (0.43 and 226.8 ppm), the Isoptera were highest, this shows the insignificant relationship of isoptera with organic carbon and available nitrogen. Similarly when the phosphate content was minimum, the Isopterans were lowest, it shows the significant relationship with Isopterans. Where as Diptera shows the insignificant relationship with phosphate. Isoptera also shows significant relationship with potash content because when the potash become lowest, the number of Isopteran was also minimum. The soil biodiversity is richly supported by pterygote as well as apterygote insects and mites. The apterygote population, in this grassland site was represented only by order Collembola and Diplura and among Acarina mainly the prostigmate and mesostimate mites.

The collembolans and Diplurans were found maximum during monsoon months. Their population was maximum in the months from March to July. During these months the atmospheric temperature is very high and the relative humidity is also very high (44°C and 100%) the weather is dry. Extreme dryness and heat effects the growth of grasses. The grassland becomes dry and without grass absence of soil moisture also results in low population of soil microarthropods.

Similarly Tsiafouli Maria A. et al. (2005) studied on the responses of soil microarthropods to cxperimental short term manipulations of soil moisture and gave their opinion that drought decreased soil water content as well as microarthropod species richness and increased maximum soil temperature.

Collembolans are known to with stand a wide range of temperature of 55°C in desert (William et al 1987). Earlier reports of collembolan thriving at 55°C were given by Agrell

(1941) and Davis (1963). The thermal preferences of Collembola and Acari were investigated within a temperature gradient (-3 to +13°C) under 100% relative humidity conditions, by Hayward S.A.L. et al. (2003).

The soil moisture also have a positive correlation on the population of the soil insects. The population of Collembola, Diplura and Acari were moderate in the grassland. When the soil moisture was maximum in the month of January, the population of Collembola was highest. Our observations fall in accordance with the findings of Block W. (1981), Verhoef, H.A. and Van Sleen A.J. (1985), coulson S.J. et al. (1995), Huhta Veikko and Hanninen Sanna - Maria (2001) and Lindbery N. and Bengtsson (2005).

The collection of Folsomia (order: Collembola) in a large number in the month of January, is supported by the finding of (Bakonji, G 1989) where the microbial biomass of the grassland supports rich population of Collembola.

Now the next important edaphic factor is soil pH varied between 7.4 to 7.7. It had little or direct effect on the population of soil microarthropods. Our results are supported by the observations of Bath (1980) who stated that acidification also has a marked influence on the sub-soil insects.

The organic carbon content of the soil of this site varied between 0.43 to 0.58% and exhibited a strong correlation with the insectan population along with Acarina. The relationship of Collembola with organic carbon significant as compare to Diplura. The concentration of population of Apterygote, Pterygote and mites in grassland suggested their affinity of organic matter. The texture of soil seemed to influence the amount of organic carbon. Rodriguez (1964) has observed large population of various soil mites on the surface of soils particularly that of organic nature. According to him organic debris of any type and its associated microorganisms on the surface provide the necessary substrate for Collembola. This might account for the abundance of Collembola and other insects in the present investigation. Similarly Vreeken-Buijs M.J. et al. (1994) studied microarthropod biomass. C – Dynamics in the below ground food web of two arable farming system. Filser, J.I. (2002) observed the role of Collembola in carbon and nitrogen cycling in soil.

Now it is an established fact that phosphate which is present in very low amount, has positive correlation with some insects. It seems that there was little marked variation between the phosphate constituent of soil. So there is insignificant relationship between the soil faunal population and the phosphate except in Coleoptera and Acari. Choudhoury and Roy (1972) supports our findings in which they observed either positive or negative correlation of collembolan population with phosphate content.

The amount of available nitrogen which ultimately change into nitrate through the process of Nitrification varied between 226.8 ppm to 256.2ppm and there was a slight increase when the temperature decreased and when the collembolan population rise up suddenly the breakdown of arthropod excuvie by bacterial action starts in rainy season and because of this reason the nitrogen content of soil increases. Belfield (1970) has observed excreta of arthropods unaffected by the bacteria during dry season when subjected to rapid bacterial action induces population rise through increase in nitrogen content. The available nitrogen being the most essential macronutrient for the plants probably exerts its influence on soil insects and mite population.

2. Teak Plantation:

Plantations are a part of Agroforestry schemes planned by the government to serve the ecosystem and create a green belt. The second site of our experiment was a Teak plantation (*Tectona grandis*) our campus has teak plantation at two different location along side various department. The idea was to beautify the campus as well as enhance the fertility of soil.

The introduction of sustainable development principle has lead to an increasing attention towards concepts such as soil quality and soil health. Soil quality is the quality of soil to functions effectively as a component of a healthy ecosystem (Circogardi et al. 2004).

The teak leaves are fairly big in diameter, but the leaf fall is annual. The area being adjacent to road is also under the influence of vehicle population and human intervention. The litter deposition is negligible as the leaves are picked up b local residents as they use them as fuel. The soil profile also gets disturbed once in year by tillage. Tree shade does not allow the floor of this artificial forest to become green. Hence presence of fungus is seen only in the months of monsoons on the floor.

Humus formation is negligible as the leaf deposition is negligible. The influence of litter and human has been studied by Walwork (1959) who observed the influence of litter and humus on soil mites. Plant litter can influence the activity of soil microbes and fauna by providing then with a food source habitat. (Zak et al. 1988, Lindberg N. et al. 2005, 2006 and Bengtsson et al. 2008).

The population of pterygotes from this site comprised of Isotera, Diptera, Coleoptera and Hymenoptera. The presence of pterygotes is also attributed to the edaphic factors and atmospheric factors. There is either positive or negative correlation between temperature, moisture, pH., organic carbon and available nitrogen. In case of Isopterans Rajagopal (1983) stated that the population density and fluctuation in cast composition with seasons vary from species to species).

The Apterygote and Acari population was quite variable. We were not able to collect the collembolans in very large numbers in any month of year as compared the catch of acari was very good through out the year.

When we compare the population with the edaphic factors it becomes clear that through the soil temperature and moisture was suitable for the microarthropod population still they were not collected in large numbers. Reasons we tried to analyse.

According to Hattenschwiler Stephan et al. (2005) the biodiversity and litter decomposition in terrestrial ecosystems shows empirical and theoretical evidence for the functional significance of plant litter diversity and the extra ordinary high diversity. When there is rich plant litter on the floor the decomposer community well be on a higher side.

The population of insects and Acari from the plantation site all were statistically proven to be falling in line with the observations of the previous workers. The low and high of the population is also interrelated with the edaphic factors. Hence for the sustenance of the sub soil system and also for the health of the soil. The sub soil fauna play an important role.

As the role of edaphic factors it might be assumed that the factors studied in this study exerted significant or insignificant effect. So in this present investigation the role of temperature, soil moisture, relative humidity, pH, organic carbon, phosphate, available nitrogen and potash along with the population of soil microarthropods will be considered one by one.

Among the edaphic factors studied temperature showed a marked variation with the change of season ranging between 15^0C to 34^0C. Physical factors like temperature, moisture being interlinked are perhaps inseparable in natural conditions. Asraf

(1971) proposed that 30^{0}C was the optimum temperature for the species of Collembola (Salinamultisceta, Isotomurus, Punetiferus and Seira iricolor). Haimi Jari et al. (2005) studied the impact of Co_2 and temperature on the soil fauna boreal forest. Similarly Choi Ti Won (2006) postulated a modeling study of soil temperature and moisture effects on population dynamics of *Paronychiurus Kimi* (Collembola; Onychiuridae) and suggesting that soil moisture is a major limiting factor on field population of *P. Kimi.* Temperature tolerance in soil microarthropods studied by Malmstrom A. (2008). In the present investigation it may be noted that direct influence of temperature on distribution pattern is difficult to evaluate because in this study the insects belong to different orders in which Collembola and Diptera is positively correlated with the moisture as compared to other members of the insectan population.

Christainson (1964) have quoted that temperature regular the reproduction of springtails but the role of moisture is equally important in regulating and synchronissing the reproductive activity hatching and mortality in many *Entomobryoids.* According to them because the rate of development in Collembola is directly related to temperature which supports our findings.

The shade of teak trees reduce the rate of evaporation and hence the moisture allowed the presence of Apterygote and Pterygote insects with Acarina throughout the year. So, this was the reason for abundance of Apterygote and Pterygote insects.

The rise in temperature is expected to cause greater evaporation from litter making it dry and hence minimum population in summer. The negative correlation shown by temperature may be explained in terms of the fact that it can not be evaluated unless it is considered in conjunction with atmosphere.

The soil moisture is an important factor governing the survival of the soil biota. The moisture content of soil exhibited a wide range of variation (minimum 0.30% and maximum 4.27%) at this site. Increase in moisture content promote the growth of fungi which is the chief food for termite, Collembola and Oribateid mites. Humidity was the most important factors determining distribution, abundance and survival of soil Collembola in the tropical forest (Wiwatwitaya D. and Takeda H. 2004). In the opinion of Triafouli Maria A. et al. (2005) the collembolan community showed higher species eveness and diversity in the frequently irrigated plots. Our results indicate that irrigation pattern will have an impact on soil ecosystem in complicated, non linear ways.

The relationship between the insects both the Pterygote and Apterygote with Acarina collected in the study was statistically analysed. The correlation and regression between Apterygote and Pterygote with soil moisture and soil temperature was highly significant in this study.

The value of soil pH throughout the year from the sampling site remained acidic. The insectan population was maximum when the pH ranged between 7.4 to 7.7. According to Davis (1963) pH variation can not be separated from that of organic carbon and porosity of soil. Similarly Xekin et al. (2004) studied the effect of low pH environment on the collembolan onychicrus yaodai and observed that reduced environmental pH even for a limited period, is potentially harmful to O. yaodai.

Therefore pH had very little or no direct effect on the population of soil microarthropods but it might contribute to the fluctuation of population by indirectly influencing vegetation and other physio-chemical properties of the soil.

The organic carbon content of the soil varied between 0.59 to 0.79% and exhibited a strong positive correlation with insectan population except Dipterans. This correlation should be under the influence of dry or moist conditions because soil moisture determines the density and type of vegetation, which in turn contributes the collection of organic matter in the soil. The organic matter is the source of food for the organism but it also controls the living space for the soil microorganism.

The increase in population with the increased organic matter in soil has been reported in past by Haarlov (1960), Pillai and Singh (1980), Alfred and Darlong (1982) and William et al. (1987).

Another important edaphic factor is phosphate which is present in both organic and inorganic form in the soil. In our findings, the phosphate present in the soil varied between 9.0 to 10.8 ppm throughout the period of investigation at this site. It shows positive correlation with the population of soil microarthropods except Coleoptera and Diptera. In our result, it might be suggested that relation between the soil phosphate were not regular perhaps due to the fact that all of the phosphate in the soil was not available to the living system. Our findings support Choudhury and Roy (1972) who observed either positive or negative correlation of collembolan population with phosphate content. Similarly Lindo Z. and Visser S. (2003) stated the microbial biomass, nitrogen and phospherus mineralization and mesofauna in boreal conifer and deciduous forest floors following partial and clear cut harvesting. In our findings it might be that phosphate as single factor did not exert any significant influence on the population but it in combination with any other factor might contribute to the fluctuation of other factors.

The concentration of available nitrogen in sampling site varied between 226.8 ppm to 253.4 ppm and there was a slight increase with onset of monsoon. They show the positive correlation with insectan population except in Coleoptera. However there are reports that increased nitrogen content in the soil detritous to the population of soil arthropods namely Collembola coleopterans. Dipterans also high level of cattle slurey are toxic for these organisms (Bloger and Curry 1980). According to Kunhalt (1963). Nitrogen acts as an attractant for the arthropods. Person, T. (1989) studied the role of C and N mineralization and Agarwal, R.K. et al. (1990) reported on the nitrogen response to pearl millet grown on soil underneath *P. cineraria* and adjacent open site in an arid environment.

Conclusion

CONCLUSION

Soil is an important component for monitoring of sustainability of land use in relation to both the conservation of natural resources and biodiversity of ecosystems. Soil insects and mites are extremely sensitive to variations is the ecosystem and climatic changes, hence they are used in bio-monitoring and their use in understanding the interaction between different groups of soil microarthropods and the edaphic factors.

The incidence of droughts has increased over recent years in this region where the climate has been predicted to get warmer and drier. These changes in climate, generally attributed to global warming are predicted to produce changes in flora and fauna. Sub soil insects are prone to be influenced by the changes in the climate and also the climate of the soil.

In the present study, the population of soil microarthropods has been studied in correlation with the soil fertility and soil health with emphasis on agroforestry, attention has also been focused on the effect of plantation and grasses on the population of soil insects. The soil samples were collected, one from an open grassland and the other from Teak plantation area. The present study revealed that the population of insects was higher the grassland compared to Teak plantation. The number of insectan orders and acari were almost same but their respective population showed considerable variation. Kampichler and Geissen (2005) observed the forest ecosystem is best suited for the collembolans and mites and their population decreases with depth, however in the present study we did not find any high percentage in teak plantation possibly due to the soil edaphic factors and climatic conditions.

It is generally observed that the physical and chemical factors of the soil have direct or indirect effect on the population of soil microarthrotods but our result showed a negligible litter decomposition and humus formation. It is well established that collembolans and diplurans are a strong pillars of decomposition community. We have concluded that in the absence of litter, even the soil moisture does not help the soil microarthropods to increase in number. Further due to absence of fungi and algae from the site, the collembolans feed on fungus. Hence, scarcity of food was apparently one of the reasons for their low population. Acari was good in number in the plantation site, since as they feed on collembolans. The subsoil food web is a short but a strong food chain.

The grassland site had greater pterygotan population with the predominance of collembolans in one or two months. In this work the assessment of the insectan population of the soil and also the interrelationship of the population with different physical and chemical factors revealed that no single factor is responsible for the seasonal variation of the insectan population, but all factors have a cumulative effect.

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